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Detecting Poisonous Gases by Their Action Upon Small Animals*

Experiments Carried Out by the Bureau of Mines

By George A. Burrell and Frank M. Seibert

It has been found that small animals, such as canaries or mice, are more sensitive than men to the action of the poisonous gases of mines. Advantage has been taken of this fact to give a timely warning to mine workers and rescuers, of the presence of such poisonous gases.

It must be remembered that many mines extend for three miles or more from the entrance, and bad air from explosions etc., in one part of the mine does not necessarily affect in any large measure some of the more remote parts. In carrying on rescue work there may be hundreds of men to be rescued by a gang of only four or five helmet men. In such cases it is customary for volunteers without helmets to go as far as they with safety can, and to aid the helmet men by taking in charge the members of the rescued party, as they are brought to them by the helmet men. The volunteers carry with them canaries, and so long as the birds appear bright and preen their feathers, the volunteers know they are safe from bad air, but if the canaries show distress, the volunteers have to retreat to another and safer base.—Editor.

The usefulness of small animals in detecting vitiated air in mines is well established. The Bureau has experimented with most of the more common small animals, such as canaries, guinea pigs, rabbits, chickens, dogs, mice and pigeons, and finds that canaries or mice are the most suitable for the work. This finding is in accord with the observations of J. S. Haldane, who states that the time required for symptoms of carbon monoxide poisoning to appear (or disappear) is proportional to the respiratory exchange per unit of body weight. The Bureau finds canaries to be the most sensitive. They were used in England before their acceptance in this country; presumably in places on the Continent also. Their usefulness in husbanding the resources of breathing apparatus is of great importance.

An additional reason for the use of canaries lies in the fact that they are generally easily obtainable, and become pets of the men who have them. If handled intelligently in rescue operations, they seldom die as a result of their exposure to carbon monoxide.

EFFECT OF REPEATED EXPOSURE TO CARBON MONOXIDE.

Canaries, mice and guinea pigs were repeatedly exposed to carbon monoxide under different conditions. In some experiments they were exposed to

(Continued on page 389.)

* Paper presented before the Coal Mining Institute of America, Pittsburgh, Pa., December 4th and 5th, 1913. Published with the permission of the Director of the Bureau of Mines.

A scene at an actual mine disaster. Volunteers waiting for helmet men to bring injured to this safety base. Miners feel secure as long as the bird remains on its perch.

The Limiting Size of Steam Turbine Units*

In Land Practise the Limit is Fixed by Difficulties of Transportation

In any really large power-station the size of the units to be installed is a matter deserving of very careful consideration. In the earlier days of power-station development, great subdivision of the plant was natural, since breakdowns, complete or partial, being somewhat prevalent, security was sought in a somewhat minute subdivision of the plant into relatively small units. In general, however, the cost of providing for a given aggregate output is greater the greater the number of units. For this there are several reasons, but one important factor at any rate is well brought out in the instructive paper on large turbine units, contributed last January to the *Proceedings* of the Rugby Society of Engineers by Mr. J. P. Chittenden. In that paper it was shown that what may perhaps be called the "non-effective" costs of a steam-turbine are proportionately very much greater the smaller the unit. The costs in question comprise that of the governor and its gear, the valves, the oil-pumps, tachometer, and similar accessories. In the case of a 500-kilowatt unit, the cost of these amounts, Mr. Chittenden states, to about 45 per cent of the total cost of construction, falling, in the case of a 1,000-kilowatt unit, to 40 per cent, and in the case of a 10,000-kilowatt turbine to 30 per cent. Hence, even if the "effective fraction" of a complete turbine cost the same per kilowatt for a small unit as for a large one, the total costs would be more with the smaller sizes. Actually this argument understates the case for the larger unit. In fact, the same casing is sometimes used for a 5,000-kilowatt machine as for a 7,000-kilowatt unit and at the same speed of revolution, so that the turbine costs proper are almost identical, though some saving results from a smaller condenser being required with the smaller output. At the same time, the floor space occupied will be greater the greater the number of units, and in general the efficiency of small prime movers is markedly less than that of larger ones.

To this rule the internal-combustion engine forms an exception, the efficiency attained with an engine of about 60 horse-power being about as high as with an engine ten or twenty times as large. Hence, with stations operated by gas or oil power, an increase of efficiency does not form one of the arguments to be adduced in favor of installing units of large size, the lower limit in such a case being, in fact, fixed wholly by financial considerations. Whatever the agent by which a power-station is operated, there is, however, also an upper limit to the size of the unit which it is desirable to adopt. In most cases this is continually being raised by the progress of the engineer's art, but there does appear to be, for the present at any rate, a very definite "mechanical" limit so far as internal-combustion engines are concerned. In the case of a gas-engine, for example, it is a deduction from theory, which has been confirmed by actual practice, that the weight per horse-power developed is proportional to the cylinder diameter, so that doubling the size of an engine, though it quadruples the output with the same piston speed, requires the incorporation into the engine of eight times the weight. Moreover, cylinders of very large diameter are subject to extremely severe temperature strains, and it has generally been considered that about 48 inches constitutes the practical limit to the size of a gas-engine cylinder. This conclusion may possibly be, however, considerably modified in the future by Prof. B. Hopkinson's method of spraying water into the cylinder.

With some other forms of prime mover the limit of size is far less definitely circumscribed by purely mechanical considerations. Theory shows that such a limit must exist, since all prime movers are, in the ultimate, subject to the law that while the output increases as the square of the dimensions, the weights involved increase as the cube. For the present, at any rate, this consideration hardly affects the question as to what is the limiting size of a steam-turbine unit. This is, in practice, fixed by difficulties of transport and by the high cost of exceptionally heavy castings and forgings. If a power-station is intended to furnish a three-phase supply at 25 periods, the turbo-alternator must run at either 750 or 1,500 revolutions per minute. If the former be chosen, the limits of size are pretty definitely fixed by questions of transport, the loading gage on British railways restricting the diameter of a drum-rotor over the blades to about 8 feet 6 inches, and the diameter of a disk to about 13 feet; though by making special arrangements, sizes a little larger can be transported at a pinch. As in land installations rail transport is a practical necessity, the question of the limiting size permissible is thus narrowed down to these normal conditions of transport general overland.

An interesting point which then arises is the maximum output possible with rotors of the dimensions stated. This output depends essentially on two factors; the centrifugal stresses and the vacuum obtainable. Condensing plants have been so much improved that with a barometer of 30 inches a vacuum of 29 inches should be realized during a large fraction of the year, as is, in fact, effected at some of the power-stations on the Northeast Coast. Incidentally, it may be observed that the great economy of fuel which results from the systematic adoption of high vacua makes it imperative to fix all large power-stations at sites where an ample supply of condensing water is readily available. As delivered from an efficient turbine, however, the volume of 1 pound of steam at a 29-inch vacuum is of the order of 600 cubic feet, making an average allowance for the wetness of the exhaust steam. If this steam is allowed to have an axial velocity at discharge of 440 feet per second, and the blade length is limited to one fifth the mean diameter of the blading, the output of the turbine in kilowatts cannot exceed the square of the mean diameter, in inches, of the last row of blades, assuming the very good steam consumption of 11½ pounds per kilowatt-hour. If, therefore, we assume that the last row of blades is carried on a disk 13 feet in diameter over blade tips, the maximum output possible from a single-flow turbine operating with a 29-inch vacuum, and with a "carry-over" loss of about 4 British thermal units, would be about $130^2 = 16,900$ kilowatts. By admitting a carry-over loss of 9 British thermal units, this output could be increased to about 25,000 kilowatts. If the vacuum were limited to 28 inches, the possible output would amount to about 33,000 kilowatts, with a carry-over loss of 4 British thermal units, and to about 48,000 kilowatts with a carry-over loss of about 9 British thermal units.

Allowing for a reheat factor of, say, 1.05, the heat available with steam at 200 pounds absolute and 200 deg. Fahr. superheat, expanded down to a 28-inch vacuum, is about 391 British thermal units per pound; while if the expansion be carried down to the 29-inch vacuum, the corresponding figure is about 428 British thermal units. An exhaust loss of 4 British thermal units amounts, therefore, to about 1 per cent of the total energy available, and one of 9 British thermal units per pound to about 2¼ per cent. To get 33,000 kilowatts out of a single-flow turbine with a 29-inch vacuum would necessitate an axial velocity at discharge of about 880 feet per second, and the carry-over loss would amount to nearly 16 British thermal units. An increase of vacuum from 28 inches to 29 inches would therefore still result in a saving of steam, since the heat available on expansion to the lower limit is about 37 British thermal units more. An attempt to get 48,000 kilowatts out of the turbine with a 29-inch vacuum would, however, be futile, as the "carry-over" losses would be so greatly increased as to cancel almost the whole of the difference in the heat available with a 28-inch and a 29-inch vacuum.

There would, of course, be no difficulty in running a wheel of the size proposed at 750 revolutions per minute. In fact, experience with the De Laval turbines shows that the speed might be raised to 1,100 revolutions per minute without exceeding limits of stress known to be safe in practice. A 300 horse-power De Laval wheel has a mean diameter of 30 inches, the blades being about 1¼ inches in usable length, and the speed 10,600 revolutions per minute. If every part of the wheel were increased in direct proportion up to a mean diameter of 130 inches, the stresses would be the same as before, provided the revolutions were reduced in the ratio of 30 to 130, that is to say, to 2,440 revolutions per minute. The blade length would then be

$$\frac{1.25 \times 130}{30} = 5.5 \text{ inches nearly.}$$

If the length of these blades were next increased to 26 inches, which is one fifth of 130, their weight and the stresses in them would be about 4¾ times as great, so that to bring down the stress to its original limit the speed must be divided by $\sqrt{4.75}$, being thus brought down to 1,125 revolutions per minute. If the ratio of blade speed to steam speed were the same with the 26-inch blades as with the 6½-inch blades, the bending stresses produced by the steam which drives them would be the same as before, and the margin of security as great as in the original De Laval wheel. This increase of blade length would, of course, involve a diminution in the size of the wheel disk, so that the total stresses in the latter would be less than they were in the original wheel. By constructing the low-pressure portion of a turbine on the double-flow system the limiting outputs above stated may, of course, be doubled, and hence very great outputs are mechanically feasible in single units.

For the present, however, the practical limit for a turbine running at 750 revolutions is probably about 25,000 kilowatts, and if of the drum type, questions of rail transport make it necessary to construct the rotor for such an output on the double-flow system. The casings are less difficult to deal with, as they can be built up in sections. The total weight of such a turbine would be between 250 and 300 tons, that of the heaviest part to be lifted being between 30 and 40 tons. The sizes of the various forgings required would be, however, about up to the limit of what can now be obtained, and the cost per ton of these very large forgings and castings is very considerably more than those of more moderate size. It is, therefore, perhaps, open to doubt whether units of this size are, save in exceptional cases, more advisable than those of about one half to two thirds the capacity in question running at the alternative speed of 1,500 revolutions per minute. The last row of blades might then have a mean diameter of 85 inches, or a tip diameter of 8 feet 6 inches, and the output, without extravagant losses to the exhaust, might run up to fully 14,000 kilowatts. If of the double-flow type, the highest economy could be attained with quite moderate stresses. The limit is, of course, the same for impulse as for reaction turbines, as was very clearly set forth in Mr. Gerald Stoney's able contribution to the discussion on the very valuable paper read by Mr. K. Baumann before the Institution of Electrical Engineers in 1911. As he then pointed out, the last rows of blades for a reaction turbine to be operated near its limiting output would be carried by disks, a well-known form of construction presenting no mechanical difficulties. A turbine of this output, at the speed stated, could be carried on rail without dismantling the rotor, and the top and bottom halves of the casing could be shipped complete. Its total weight would be about 50 to 60 tons, and that of the heaviest part would not exceed 20 tons. It will, therefore, be seen that the output per ton is much more at 1,500 revolutions than at 750 revolutions per minute, which is easily understood when it is remembered that the efficiency of a steam-turbine largely depends on the "velocity ratio," or the ratio of blade to steam speed, which again, with given steam conditions, depends on the "coefficient" or the revolutions² × mean diameter² × number of rows of blades. For a stated number of revolutions this coefficient is obviously approximately proportional to the volume of the turbine-casing. It is thus seen that the volume of the turbine-casing, and therefore the weight, is only about one quarter for 1,500 revolutions per minute of that required for 750 revolutions per minute. The smaller weights to be handled at the higher speed means, moreover, a much lighter construction of the engine-house, smaller cranes and less massive foundations.

There would, it appears, be no difficulty in constructing an alternator of this output to run at the speed named. Speaking last year at the American Society of Mechanical Engineers, Mr. Hodgkinson stated that the Westinghouse Company were building alternators to run at this speed with a normal output of 15,000 kilowatts and a maximum of 20,000 kilowatts. At Marylebone the Oerlikon Company are installing a 3,000-kilowatt machine to run at 3,000 revolutions, capable of carrying an overload of 4,200 kilowatts for six hours, which is equivalent to carrying it continuously. Since the output of an alternator varies nearly as the inverse square of the revolutions, or, by the same law as that of the turbine, it should be as easily practicable to build a unit developing 12,000 kilowatts to 14,000 kilowatts at 1,500 revolutions per minute. In the discussion on Mr. Baumann's paper already referred to, it was stated by Mr. Davis that the A.E.G. were building a number of alternators to give 5,000 kilowatts, or 5,600 k. v. a. at 3,000 revolutions per minute.

In view of the ease of carriage, the light weights to be handled, and the facility with which the turbine could be dismantled when required, it would seem that the smaller high-speed plant is really much to be preferred to the larger, and since the weight per kilowatt is less, the cost should also be lower, particularly in view of the high price of very large castings and very heavy forgings, to which attention has already been called. Moreover, with the very large structure, distortions, due to its own weight and to

* Reproduced from *Engineering*.

temperature variations, are more pronounced, making it necessary to adopt clearances proportionally larger in the larger unit, so that the smaller machine might actually prove the more economical under test, though data on this point are still lacking.

When the supply has a periodicity of 50 per second, another possible speed is 1,000 revolutions per minute; but here again it is quite questionable whether, on the whole, a 20,000-kilowatt to 25,000-kilowatt unit at this speed is really to be preferred to two 12,000-kilowatt to 14,000-kilowatt machines running at 1,500 revolutions per minute. Several plants giving 15,000 kilowatts to 20,000 kilowatts at speeds of 1,000 to 1,200 revolutions per minute are in hand both in this country and abroad. A photograph of one made by the A. E. G. to give 20,000 kilowatts at 1,000 revolutions was included among the illustrations given in Mr. Baumann's paper.

Did the Horse Exist in America Before This Continent Was Discovered By Europeans?*

By Prof. E. Trouessart of the French National Museum of Natural History

There are certain erroneous notions that rise from their ashes, like the Fabled Phoenix, and are adopted without discussion or examination. Such is the tradition that the domestic horse existed in America before the advent of Europeans. Cardoso, a naturalist of Argentina, has recently endeavored to give a scientific basis to this opinion, which is controvested by a mass of historical and scientific evidence.

I. HISTORICAL EVIDENCE.

All historians of the conquest of America agree in affirming that horses were entirely unknown to the natives, who fled in superstitious terror from the Spanish horsemen.

Herrera, describing a Spanish sortie on the Isthmus, in 1816, says: "Three thousand Indians had assembled, but when they saw the horses they became so terrified (for they had never seen such animals) that they fled." Again, in describing a noctunal attack, he says: "As soon as they perceived the horses, they fled in fear of being divoured by them." Many similar passages could be quoted.

Diaz tells us that Cortez, in his first invasion of Mexico in 1519, had eighteen horses, which decided the issue of a battle at a moment when the Spaniards were about to be overwhelmed by numbers. Subsequently, when the natives had succeeded in killing one of the Spanish horses, "they cut it into pieces to show in all their villages."

In concluding his history, less than thirty years later, Diaz asserts that the natives had become excellent horsemen and that there were more than "ten thousand mares" in one small district of Mexico.

Xeres, the historian of the conquest of Peru, is equally explicit, and his narrative shows that Pizarro's companions skilfully exploited the fear inspired by their horses, for which the natives could find no better name than "big sheep."

The Inca Garcilasa de la Vega, in his History of the Incas (1616) says that the ancient Peruvians had "neither horses nor mares." "The Spaniards brought horses to Cuba and San Domingo, where the animals multiplied and furnished horses for the conquest of Mexico and Peru." The author explains that a stock of wild horses was introduced into the islands by the escape of a few brood mares.

Mendoza, the founder of Buenos Aires, left behind him seven horses and five mares which, with some later importations, were the ancestors of the wild horses of the pampas.

In Brazil, according to Liéry, horses were introduced by the Portuguese, about 1560. Vespucci, the first European to land in Brazil (1501) says, "all species of animals there are wild and entirely unknown in Europe."

The partisans of the pre-Columbian American horse adduce the figure of a horse which adorns the region of Argentina on Sebastian Cabot's celebrated map of the world (1531). But Cabot indicates, in the same region, mines of gold and silver, which had no existence, and we know that the natives obtained these metals from Peru. Probably Cabot wished to indicate that the pampas offered a field favorable to the breeding of horses, as the sequel has proved. The explorers of that period employed every means to attract colonists.

II. GEOLOGICAL AND PALEONTOLOGICAL EVIDENCE.

The fruitful researches of American geologists and paleontologists have proved that veritable horses, belonging to the genus *Equus*, lived in both Americas during the first half of the Quaternary or Pleistocene period. North America possessed at least twelve species, which ranged in size from that of a small ass to that of the largest modern draught horse, but which did not all inhabit the same territory. In South America nine species have been described. At least one of the six or seven species that inhabited the northern part of the Old World at the same epoch still survives, but all of the American species are extinct. The explanation of their disappearance will be given in the physiographic and zoological evidence.

For the present let us examine the purely geological evidence that the Quaternary horses of Argentina were extinct long before the domestic horse made its first appearance. The Quaternary strata of Argentina have been studied with great care by Amezhino, who gives the following table of their mammalian fossils.

Strata	Mammalian fossils.
Aerial (present)	*Equus Caballus domesticus.*
Aimara (recent)	*Auchenia guanaco* (llama), not a vestige of *Equus.*
Platian (lacustrine)	*Equus rectideus, Mastodon Supertus*
Querandian (marine)	No terrestrial mammals.
Pampean (four stages)	*Equus rectideus, E. Argentinus, E. Curvideus, etc.*

This table shows, with great clearness and precision, that the indigenous horse disappeared at the end of the Platian, i.e., in a period of lacustrine depression, following a period of marine invasion. In the following period (Aimara) the land rose and became firm. The Aimara stratum contains remains of the llama, but none of the horse (*Equus rectideus*) which would have become fossilized in the same conditions, if it had existed. This stratum represents a period of several thousand years, which intervened between the extriction of *Equus rectideus* and the appearance, in quite modern times, of *Equus caballus*, the domestic horse.

It will be observed that the mastodon disappeared at the same epoch and in the same conditions. An analogous fact was observed in North America, where all the large ungulates of earlier periods (except the llama and the tapir) became extinct, and were replaced by ruminants (bison, deer, etc.), which came from Asia before Bering sea was found. Hence the extinction of the genus *Equus* is less surprising than it appears at first glance, since an entire fauna vanished at the same time.

The mammoth (*Elephas primigenius*) and the *Equus caballus* came subsequently from Siberia by the same route, but neither of them penetrated far southward. Remains of the *Equus caballus* have been found in Alaska and Canada, but the species became extinct in these cold regions long before it was brought to tropical America from Europe, as a domestic animal.

III. PHYSIOGRAPHIC AND ZOOLOGICAL EVIDENCE.

Let us seek the causes of these extinctions, which many naturalists still regard as an unsolvable problem.

In the first place, let us consider the physiographic character of the region now inhabited by wild Equidae, including horses, asses, zebras, etc. This region extends from northeastern Asia to southwestern Africa, and includes the desert of Gofi, Dzungaria, Turkestan, Persia, Syria, Arabia, Somaliland, and Africa south and west of the Great Lakes to the Congo. This entire region is between 2,000 and 3,000 meters above the sea level and most of it is covered with grasses and grains, which form the sole food of the Equidae. The soil is always dry and, consequently, well adapted to the single hoof, which sinks in muddy and boggy land. No insuperable barrier separates the eastern from the western part of the Sudan, or the Zambesi region from the Congo basin, yet the zebra, which abounds in the east and south is entirely lacking in the northwestern district, which is less than 1,000 meters above the sea level.

The altitude of the American continent, east of the Rocky Mountains and the Andes, is only from 800 to 1,000 meters. The Pacific slope presents greater altitudes but this narrow mountainous strip has been disturbed by many volcanoes, whose activity during the Quaternary period, is attested by the great lava beds. East of the mountains, on the other hand, the Quaternary glaciers have planed the land and excavated the Great Lakes, so that we may say that the soil of North America has been incessantly disturbed in modern geological times, by water in the east and by fire in the west.

In these conditions the extinction of the great Lestiary ungulates is easy to understand. The three-toed Equidae (*Hipparion, Protohippus, Pliohippus*, etc.), which in the beginning of the Quaternary had shed their lateral toes, useless on firm soil, became victims of this too perfect evolution when the climate became at once very wet and very cold, for the single hoof of the horse sinks in mud and snow and slips on ice.

The principal cause of the extinction, however, was the disappearance of the grassy prairies beneath a layer of ice. The American Pleistocene species appear to have been narrowly localized and they lacked the resistance possessed by *Equus Caballus*, an Arctic and widely distributed species which, however, now exists in the wild state (*Equus Prjewalskii*) only in one small district in Asia, although that continent was not ravaged by glaciers.

The southern part of North America also escaped the action of glaciers, but here we find a veritable desert, extending from the Bad Lands of Nebraska to the *Llano Estacado* of Texas and to Mexico, which was unable to furnish sustenance for large mammals. South America was subjected to the same vicissitudes as North America, from which it received its present ungulate fauna after the elevation of the Andes and the Isthmus of Panama. By this route came the horses, which left their bones in the Quaternary strata of South America. The fate of these species (*Equus rectideus, E. curoideus, E. argentinus*) has been described in connection with the table of Argentine Quaternary strata. The remains of the domestic horse (*Equus caballus*) found in the latest and quite modern deposits are easily distinguishable from those of *Equus rectideus*, which became extinct hundreds of centuries earlier.

Here, also, the extinction of the large herbivera, and especially of horses, was caused by deficiency of altitude and lack of suitable food. The grass a pampas were in existence at the beginning of the Quaternary period. Subsequently they were submerged beneath the waters of the Atlantic and, still later, they were raised and gradually restored, passing at first through a lacustrine period and finally becoming dry enough to furnish a soil suitable for horses imported from Europe.

The humidity of the soil has suggested to Mr. Henry Fairfield Osborn a different and very ingenious explanation of the extinction of the ancient American horse. In Africa, in many instances, the large animals of extensive districts have been destroyed by the tse-tse fly (*Glossina*). Now Mr. Cockerell has found two flies, which he refers to this genus, in Miocene deposits in Colorado. It is possible, therefore, that epizootics similar to those of Africa, raged among the ancient horses and other large herbivera of America, but this, in my opinion, was only an accessory cause of extinction. It is difficult to believe that any parasite could destroy an entire fauna, and we know that all of the large American ungulates, including elephants and mastodons, vanished at the same time. Geological causes and the resultant climatic changes (long continued rainfall, subsidence of the ground, inundations, glaciers, scarcity of vegetation) have certainly been more potent factors.

I shall not dwell long on the zoological evidence, which is difficult to discuss without reference to specimens or drawings of the skulls and teeth of the species in question. M. Cardoso's opinion is evidently based upon such specimens, but every naturalist knows the close resemblance exhibited by single bones of the various species of *Equus*. A very careful comparison is required to distinguish the skull of a zebra from that of a horse of the same size. Many naturalists maintain that our domestic breeds have resulted from the crossing of two wild species: the Western horse, closely resembling the *Equus caballus*, widely distributed in Europe in the Quaternary period; and the Eastern horse (improperly called Arabian, for it is rather Syrian or Persian) descended from a species of southern Asia. These same naturalists cannot agree whether the wild horse of Dzungaria (*Equus Prjewalskii*) should be regarded as a distinct species, or as a sub-species or local variety of *Equus caballus*. Similarly, Lydekker contends that the two Argentine fossil forms, which Ameghino distinguishes as *E. rectideus* and *E. curvideus*, are not specifically separable. These divergences of opinion show how closely the species of *Equus* resemble each other in their osteology, and especially in their dentition.

Finally, if the Argentine horses that for many years, have been imported into Europe, are descended from a distinct American species, it is strange that no naturalist or veterinary has noted any specific differences between them and European horses.

*Translated for the Scientific American Supplement from the *Revue Générale*.

Hale's bar lock and dam, near Chattanooga, Tennessee.

Hydro-Electric Power for a Southern Industrial Center

A Nine Million Dollar Plant for Chattanooga

It may well be said that a new era for the entire region around, from the standpoints of navigation and industry, was opened up on November 13th with the formal dedication of the Hale's Bar lock and dam at Chattanooga, Tenn. The dam serves a double purpose. It impounds a great volume of water, making the river a veritable lake for forty or fifty miles above, and adding several months yearly to the navigability of the stream. It also furnishes 65,000 horse-power to industry and commerce. The power house is equipped, and current was first turned on November 13th by the little granddaughters of the deceased promoters. The completed development represents an investment of about $9,000,000.

The Hale's Bar project is peculiar, looking at it from the standpoint of the national improvement of waterways, in that it is the first instance where a private company was permitted to construct a dam across a navigable river, or, in other words, where river improvement and power development have been combined. The entire work has been done under supervision of the Secretary of War. The developments on the Mississippi River at Keokuk and in Alabama are other and later examples of the co-operative policy.

The lock, at opposite end of the dam from the power house, is built against a rock bluff, and has a clear width of 60 feet. It is about 300 feet long inside the gates. The lower gates are 59 feet high, the highest single lift in the world. Each leaf of the gates weighs 129 tons. The dam is 1,200 feet long; its average height is 52 feet; it is 11 feet 4 inches wide at the top and from 57 to 64 feet wide at the bottom, according to the depth of the foundation. The power house is 66 feet wide and 353 feet long. It contains fourteen turbine units, each capable of delivering 5,250 horse-power, or a total of 73,500. The power from this station will be carried to Chattanooga at 40,000 volts over 175 steel transmission towers, the line crossing the winding Tennessee River twice in order to maintain a straight course. A sub-station in the city, not far from the river bank, has equipment to step down the current for the various uses to which it will be put in this, the only city to which the company proposes to deliver power. Completion of the Hale's Bar plant makes some 150,000 electrical horse-power available here, the balance being derived from the Ocoee River plants. Chattanooga is already the leading manufacturing center of the South. The incentive to new industries furnished by this great amount of cheap power, added to the many advantages which the city has by reason of its location, many railroads, resources such as coal, iron, timber and others, will inevitably add very much to her pre-eminence industrially.

The new Chattanooga hydro-electric power station represents one more in an ever-growing army of these servants of mankind.

"The use of animal energy," says a writer in the *General Electric Review*, "and the discovery and application of the chemical energy in coal, and finally the use of electricity for the useful service of man, have been milestones in human progress, and life itself has now become dependent upon the proper distribution and use of energy, so that it must now be added to the necessities of life and rank in importance with food and clothing. Indeed, it would be impossible to supply the requisite food for any city of any size on this continent for a day if our system of energy supply were to fail.

"Electricity is becoming of more and more importance every day and the great generating centers and distributing systems are fast becoming the most vital factors in the lives of large communities. Dr. Steinmetz, in his recent address before the American Institute of Electrical Engineers, pointed out the curious fact that while electrical energy is the most useful, it is at the same time the least used form of energy; that is to say, its use is almost entirely confined to transmission, as it only forms a medium for transmitting energy generated by chemical or mechanical means. The mechanical energy has to be converted to electrical energy for transmission, and the electrical energy must be converted to some other form of energy before it is used, such as mechanical, heat, light, or chemical energy. The one factor which has led to the great extension of the use of electricity is the fact that it is the most easily convertible form of energy, and its extensive use is entirely based upon economic considerations. It is easier to transport electricity over a transmission line and then to convert it into any other desired form of energy than it is to transmit the chemical energy stored up in coal over a railroad, and then convert it to the desired use.

"The vital importance of electrical energy in modern life places the large manufacturers of electrical apparatus and the large generating and distribution companies in a unique position among the industries of any community. In fact, most other industries in one way or another are more or less dependent upon the electrical concerns and therefore anything which affects the progress and development of the electrical industry as a whole must be reflected in the progress of the country.

"Each new use to which we can put energy, provided that it is accomplishing useful work in an economical manner, is a step forward along the paths of progress, and extends the field of central station activities, making the central stations more and more an essential part of every-day existence."

In proportion to its weight, California redwood is the strongest conifer so far tested at the United States forest products laboratory. This strength is due to its long wood fibers.

Lock at Hale's bar. This lock is 300 feet long inside the gates and 60 feet wide. The downstream gates here shown are 59 feet high and represent the highest single lift in the world. Each leaf of the gates weighs 129 tons. The lock is built against a rock bluff.

At the recent dedication ceremonies a luncheon was prepared for the party of visitors in the generator room of the Chattanooga Power Station. The photographer has in this view caught the luncheon party and some of the principal features of the generator equipment.

Testing for Poisonous Gases in Mines by Means of Small Animals

(*Continued from first page.*)

atmospheres that distress them in about 2 minutes. In the case of canaries 0.25 per cent was used in some experiments and the animals were exposed 7 to 10 successive times. For instance, the animal was exposed to collapse, and then when it had apparently recovered (7 to 12 minutes), it was exposed again and again, the object being to see if, after many exposures to a certain percentage of the gas, they would upon subsequent exposures show distress in a greater length of time, i. e., become more or less acclimatized to the gas. No acclimatization effect was noticed. The same experiment was performed with mice and guinea pigs with the same result. Different percentages than 0.25 per cent were also used in the case of both canaries and mice. The experiments were also carried further to the extent that the same animals that had been exposed several times on one day were exposed several times the next day and on successive days.

Animals were also exposed to percentages that quickly distress them, and after removal from the atmosphere and recovery were placed in atmospheres that ordinarily do not apparently affect fresh animals. This experiment was also reversed in the case that the animals were first placed in atmospheres that do not affect them, say 0.10 per cent in the case of canaries, and then they were exposed to atmospheres that ordinarily affect them quickly to see if results different from the ordinary could be obtained. In carrying out this investigation, the results of which can be briefly told, but which required considerable time for its performance, the conditions of recovery work with the aid of small animals were kept in view. In such work, parties would usually advance until the animals showed distress. The animals would then in all probability be carried back to fresh air, and further advance, if such were made, would be accomplished with breathing apparatus. A general reconnoissance might be made with the animals to define the danger zone of the mine. In the latter event they might be exposed to proportions of carbon monoxide that would in each case cause collapse. It is possible that an animal which collapses at a certain place because of the proportion of carbon monoxide there, might upon recovery be used in an atmosphere containing a proportion that does not usually affect a fresh animal. Again, the same animal might be exposed over several successive days while a mine was being explored. It is believed that the experiments performed show that animals will not become acclimatized to carbon monoxide under the conditions surrounding recovery work in mines, and thus become less useful or even a source of danger. It might be mentioned that this question has been raised several times in discussing the use of small animals for detecting after-damp in mines.

It should be mentioned that two Canadian investigators, G. G. Nasmith and D. A. S. Graham, found that the animals finally become acclimatized by continued exposure, i. e., if a guinea pig is exposed for days or weeks to small percentages, it can finally stand exposures that would otherwise kill it, but our tests have shown that in the case of small animals which are quickly removed to fresh air (after distress is shown) and then exposed again for a reasonable number of times, this acclimatization effect is not apparent. The two methods of experimentation are not parallel. It is pertinent to add that the effect Nasmith and Graham observed in guinea pigs, an increase in the red-blood cells, has been observed in men working around blast furnaces. Blast-furnace gas contains a high percentage of carbon monoxide.

EFFECT ON DIFFERENT ANIMALS OF THE SAME PROPORTIONS OF CARBON MONOXIDE.

The Bureau has performed many experiments in order to draw some conclusions regarding the effect on different animals of the same species of a given proportion of carbon monoxide. It was found that in general a given proportion of carbon monoxide affected different animals of the same species in about the same length of time, at least as far as the application of the results to the practical use of the animals in mines is concerned, but that once in a while an animal might behave in a markedly different manner from what is expected. This is truer of mice than of canaries, yet even in the case of the latter several of them should be taken with an exploration party in order to prevent any possible errors.

THE RELATIVE EFFECT OF SMALL AMOUNTS OF CARBON MONOXIDE ON MEN AND SMALL ANIMALS.

In reading over accounts of rescue and recovery work in mines, one is impressed with the fact that some users of small animals have not been entirely satisfied with the behavior of mice and birds (especially mice) in that men have apparently felt distress before the animals became affected. The Bureau as the result of many experiments made to determine the resistance of small animals to carbon monoxide poisoning believes it has the data at hand which explain this dissatisfaction.

It was found, for instance, that almost all of the animals tried do not show sufficient distress in one hour's time with 0.10 per cent of carbon monoxide to make them valuable for detecting this percentage of the gas. In some cases the length of exposure was extended to three hours without any effects being observed. In one case only was a canary affected in so short a time as 12 minutes by 0.10 per cent of carbon monoxide. With another bird and the same percentage of carbon monoxide, distress was scarcely observable in three hours. Only a disposition to remain quiet was observed. Eight different canaries were used and six different mice. Only one mouse out of many was slightly affected in so short a time as 30 minutes with 0.10 per cent, but was not overcome in four hours. Neither chickens nor pigeons were visibly distressed. With 0.15 per cent both canaries and mice began to be affected. With 0.15 per cent carbon monoxide canaries showed distress in from 5 to 30 minutes. A mouse showed slight distress at the end of an hour. With 0.20 per cent canaries responded in from 2 to 5 minutes except in one case (35 minutes). Three mice responded in 12 minutes, and a fourth one in 46 minutes. No blood tests were made, the object being to determine the usefulness of the animals for mining work, where their behavior as apparent to the eye is the only guide. Haldane states that 0.06 per cent carbon monoxide is sufficient to produce distinct symptoms in mice. The authors of this paper do not hesitate to say that because of his greater experience in experimenting with small animals, Dr. Haldane might detect outward symptoms in a mouse that would escape the authors' attention. On the other hand, the authors have had greater experience than many of those who might use small animals in mines. Further, in the laboratory, observations are better made than in the mine, where the light may be poor. Dr. Haldane made many experiments with himself as the subject in determining the effect of carbon monoxide on men. He found that 0.12 per cent causes a mouse to sprawl in 11 minutes. Haldane felt a slight tendency to palpitation in 33 minutes. In 90 minutes he had distinct dimness of vision and hearing and a slight tendency to stagger, besides abnormal panting when he stopped the experiment long enough to run up and down stairs. In two hours' time vision and hearing became markedly impaired and there was some confusion of mind. When the mouse was finally removed from the cage it could not move about. After 18 minutes from the time of stopping, Haldane had a distinct throbbing headache which did not last long.

With 0.045 per cent of carbon monoxide, Haldane did not notice any symptoms in the four hours that the experiment was carried on, but on running up stairs there was unusual panting, slight palpitation, etc. A mouse was not distinctly affected. In defining the minimum harmful or poisonous percentage of carbon monoxide, Haldane states that 0.05 per cent in pure air is just sufficient to produce in time very slight symptoms in man, and the same percentage produces very slight symptoms in mice. He states that 0.20 per cent is very dangerous to man. With 0.05 per cent and thereabout, Haldane finds that the gas finally begins to affect man and the outward signs appear in mice.

The cage is of special construction, the handle being a container of oxygen. After the canary bird is asphyxiated it is placed in the cage and the oxygen is released, when the bird revives and sings a merry carol.

In a demonstration before 20,000 miners of the use of canaries in detecting poisonous gases, there was 0.25 per cent of CO in the cage and the man remained there eight minutes after the bird was asphyxiated.

Haldane's observations on mice are not entirely in accord with those of the author of this paper. The reasons are probably, as already stated, differences in observation. The authors are convinced from their experiments that in a mine with poor light, and perhaps only hurried examination of the animal, and by persons more or less inexperienced in the actions of the animals, mice and canaries will not usually show distress pronounced enough to give good warning with 0.10 per cent or less of carbon monoxide. Haldane's work shows that this percentage may finally affect men, a headache in 40 to 50 minutes, perhaps, or slight tendency to palpitations in less time. This condition will be a considerable time removed from actual distress or unsteadiness of movement. At the end of 20 minutes the author had only a slight headache when he exposed himself to 0.25 per cent carbon monoxide (in air). Later, however, he became very ill. Canaries collapsed in just a few minutes.

In connection with the above laboratory experiments the author has made observations regarding the use of small animals in mines. One instance is noteworthy, as follows:

A mine fire recently occurred and a sample of mine gas was obtained that contained the following constituents:

	Per cent.
CO_2	1.10
O_2	18.61
CO	0.12
CH_4	0.42
N_2	79.75
Total	100.00

This sample was obtained in a place where exploration work was being conducted. Canaries carried with the party were not affected but two of the men finally complained of a bad headache. Later when they went to the surface they became ill. One was indisposed all evening.

These facts, although they appear damaging against the use of small animals for the purpose proposed, only militate in part against their usefulness. Such animals still remain, in the authors' opinion, the best indicators we have of vitiated air in mines. Canaries will give ample warning of percentages of carbon monoxide immediately dangerous to men. When the proportion of carbon monoxide is 0.15 per cent, canaries will show distress usually in from 5 to 12 minutes. With 0.20 per cent the distress is apparent, usually in from 2 to 6 minutes. For distress to appear in men with these percentages requires much longer time, although in the case of some individuals the effects may, when they do appear, last for hours. The author has also determined this point experimentally, as have others. Men cannot stand the exposure to collapse from carbon monoxide as animals can. Canaries and mice after distress and collapse recover quickly if exposed to fresh air, only a matter of minutes usually. In the case of men exposed to collapse, recovery is often a matter of days.

In assigning reasons for the different effects produced on men and small animals by small quantities (say 0.10 per cent and under) of carbon monoxide, the author of this paper would say that it is largely a question of observation. The blood of the animal is, of course, taking up the carbon monoxide, but only slowly and to the extent that even after a long time, one hour or more, the only effect in the animal may be a slight sluggishness or disinclination to move about. Men, on the other hand, especially when moving about or doing hard work, absorb much more oxygen and hence more carbon monoxide than when at rest, and may finally feel a slight or even a severe headache in the same gas mixture that is only slightly or not affecting the animals (as far as can be observed). The men may even finally become very sick. It is not believed that any pronounced acclimatization effect is produced in an animal on a short exposure which would account for the apparent resistance. It must be remembered that a man is in an excellent position to determine effects upon himself long before distress occurs, in the case of small percentages of carbon monoxide.

When the carbon monoxide content of an atmosphere is raised from 0.10 per cent to say 0.15 or 0.20 per cent, the susceptibility of a canary or mouse to the gas is markedly increased, as judged by the action of the animal, so much more than in the case of men that a canary especially may show distress in 5 minutes, while a man may require 30 or more minutes. A man, if he exposes himself as long as this, however, may finally become very sick, and if for longer periods, may become dangerously so.

EFFECT OF CARBON MONOXIDE ON DIFFERENT MEN.

The Bureau has compiled data from different sources to show the effect produced on different persons by carbon monoxide. The fact is clearly brought out that the gas may affect different persons in a different manner. Long-standing after-effects produced in people by severe poisoning, although apparently rare, are by no means unknown. It appears to be the evidence usually that recovery from exposure is complete, but that in the case of some individuals long-standing after-effects may follow. These after-effects on different people cannot be connected absolutely with any particular degree of exposure, such as, for example, one short exposure to large percentages, repeated exposures to large percentages as usually happens in the case of blast-furnace gas, or slow exposure to collapse with small percentages of the gas, as in the case of miners exposed to the smaller percentages that are found in mines following explosions. In the case of the same individual the final blood saturation is what counts. The point is that different people may withstand different degrees of blood saturation. In the case of blast-furnace men, the same men may be exposed to collapse or severe temporary sickness time and again. Usually, as far as can be observed from their behavior, they retain their normal condition, although, as has been pointed out by Thomas Oliver, severe after-effects may linger for two years. This appears to be exceptional. An Illinois commission appointed to inquire into conditions around steel plants, found it hard to separate effects on steel workers produced by bad living conditions and those produced on some of the men by carbon monoxide, although they were inclined to the view that carbon monoxide poisoning had considerable to do with the generally poor condition of some of the employees. The exact action of the gas in producing bad nervous disorders still remains somewhat obscure. Some do not believe the action so simple as to merely temporarily deprive the system of oxygen, as in the case of suffocation, although most of the good experimental evidence points to this view. Somewhat analogous is the case of men who work at high altitudes or who suddenly ascend to extreme heights in balloons, where the oxygen tension is very low. Different individuals also may be affected differently at high altitudes. No doubt in cases both of carbon monoxide poisoning and oxygen deprivation by other causes, the idiosyncrasy of the individual plays an important part. Others have laid much stress on this point.

As regards acclimatization to the gas, it has been strikingly shown that guinea pigs may become immune. The compensation found in pigs has also been in part observed in men. The red-blood cells increase to compensate for those put out of action by the carbon monoxide. How long this may continue without pronounced distress on the part of men is a question that requires investigation.

Repeated exposure to carbon monoxide may occur in the case of miners, in those who do the shot-firing. Blasting explosives always produce some carbon monoxide in coal mines. Men may return too quickly to the working face (before gases have disappeared), to examine their shot, and thus expose themselves to percentages, usually small, of the gas. Where large shots are fired, where the ventilation is poor, and where the working faces are too far ahead of the last breakthrough, contact with harmful percentages of carbon monoxide and other poisonous gases may follow. Miners at some mines frequently go home sick from powder smoke. The general effect on them of such exposure cannot be anything but bad.

In the conduct of exploration work one sometimes hears it said that certain individuals of a party were able to withstand atmospheres that caused distress in other members of the same party. This may be true because some men are more affected than others by the same proportions of the gas, but one or two other causes must be kept in mind. After-damp in different parts of a mine, sometimes in two places quite close together, may differ much in composition, to the extent that at one place a very small and insignificant amount of carbon monoxide might be present, while at another place, close by, a harmful proportion might exist. One person in a party unknowingly might encounter the latter atmosphere while his comrades do not. Another reason usually less apparent to an exploring party has to do with the fact that the amount of carbon monoxide absorbed depends, of course, upon the air breathed. A man at rest may breathe 7 or 8 liters of air per minute. By even moderate exertion this can be increased to 3 or 4 times that quantity. It follows that if one or more members of an exploring party work harder than others they will become poisoned more quickly than the others.

The Value of Science

By John W. N. Sullivan

The word "value" is a highly ambiguous term, and in using the word its meaning should always be clearly defined. When a typical commercial man, referring to almost any human concern asks, "What's the use of it?" he means, "What is its immediate market value in terms of dollars and cents?" And this type of man was quite effectually answered by the professor who retorted, "What's the use of a baby?"

It seems incredible that any Theory of Values will ever be formulated which shall establish a clear and uniform criterion of worth; a criterion which shall apply equally to babies, soap, fireworks, the President of the United States, and Shakespeare's plays.

But without pretending to give an exhaustive definition of what we mean by value we may say, with a fair hope of being understood, that the value of science may be regarded from two points of view. We may speak of the practical value of a scientific theory, having in view the applications which depend upon it, and the effect of those applications in benefiting mankind. This statement is obscure till we define "to benefit," but it is impossible to define everything, there being only a finite number of words in the language, and we shall assume that the phrase "to benefit mankind" is sufficiently understood.

This is the line that used to be adopted by scientific men where they were suddenly put upon their defense with the brutal question, "What's the use of it?" They would stammer and hesitate and finally, with a look of relief, mutter vague phrases about "growth of industry—wireless telegraphy—Pasteur and disease—modern artillery" and the like, and all the time they were perfectly conscious of the fact that they did not study science for any of these reasons.

Nowadays they have grown more independent, and the President of a British Association section has been known to defend the study of pure mathematics for its own sake; while it has been said that a member of the Cavendish Laboratory once proposed the toast "Here's to the Electron Theory, and may it never be of any use to anybody!"

These are healthy symptoms. It is time we refused to view the universe, and all that therein is, through the spectacles of the commercial man. Let him continue to sell his oil and slaughter his pigs, and reserve his standards of value for his fellow merchants.

Prof. A. G. Webster once remarked that a steam engine was to him an interesting example of the second law of thermo-dynamics. The fact is that scientific research needs no justification on external grounds. Civilized man has a natural and insatiable curiosity concerning the laws and structure of the universe, and this mental hunger has as much right to satisfaction as physical hunger.

The mental satisfaction afforded by a theory which knits together a large body of facts is doubtless largely aesthetic. The perception of harmony and regularity in the operations of nature carries with it as intense a feeling of pleasure as is evoked by a succession of beautiful harmonies in music. Man seeks instinctively for law and order.

Science has done much for the imagination. Researches on the distances of the fixed stars revealed to us the scale on which the universe is constructed. We realize that our planet is a speck of dust swimming amid unthinkable immensities; and on the other hand, modern physics shows us that the finest grain of matter we can perceive holds within itself a multitude of complex systems whose properties are even now but dimly understood.

Whether or not these results influence commerce or industry, they are of the highest value. They enlarge man's mental outlook, which is fully as important as increasing his physical powers.

It would be difficult to maintain that, as a nation, we amount to more than the ancient Greeks, in spite of their total lack of electric street cars and steam railroads, but if such an argument were undertaken, our best way of proving our case would be to point out the great superiority of our science. The mental and moral achievements of a people, much more than their commercial and industrial greatness, determine their true worth and their influence on history.

Science, apart from its direct technical applications and the aesthetic pleasure it affords its votaries, is of the greatest value by reason of the intellectual temper, the habit of mind, that its study creates.

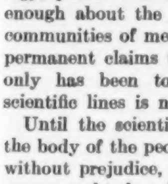
We are agreed that the present state of society is in many respects undesirable, and various panaceas have been offered for the consideration of the public. They all labor under the same disadvantage—there are not enough data. Before a satisfactory and permanently stable state of society can be constructed, a whole host of

preliminary problems must be settled. Prof. MacDougall, in his very interesting work on Social Psychology, points this out quite clearly. We do not know enough about the complex actions and interactions of communities of men to be able to frame laws with any permanent claims to value. The fringe of the subject only has been touched. More work upon strictly scientific lines is needed.

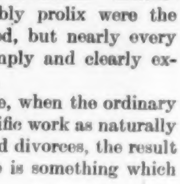
Until the scientific spirit has thoroughly penetrated the body of the people, until they have learned to think without prejudice, to disregard authority unbacked by reason, and to be critical in their examination of evidence, social reform must necessarily be a slow and halting process.

This is one reason why the dissemination of simply written accounts of scientific work is to be encouraged. We cannot all spend years in scientific study, but that is no reason why we should not largely share the advantages that a scientific training gives. It is possible to present all the great theories and results of science in a precise and accurate manner, which is nevertheless simple enough to be understood by the average man. Such simple accounts, if sincerely and competently done, are capable of benefiting humanity to a greater extent than many highly technical and recondite papers enshrined in various "Proceedings" will ever do. Some branches of science are necessarily technical. Mathematical work would be unendurably prolix were the conventional shorthand not adopted, but nearly every other branch of science can be simply and clearly expounded in a non-technical fashion.

When this is done on a large scale, when the ordinary man tries to keep *au fait* with scientific work as naturally as he does with politics, murders and divorces, the result will prove that the value of science is something which cannot be overestimated.



The Hughes Gold Medal of the Royal Society of London



Award to Dr. Alexander Graham Bell

By T. E. James

Dr. A. Graham Bell, LL.D., the distinguished inventor and physicist, has been awarded the Hughes medal, which is the gift of the Royal Society of London, for his share in the construction of the telephone receiver and invention of the telephone. The medal was founded under the terms of the will of Prof. D. E. Hughes, F.R.S., the inventor of the microphone, who in 1898 bequeathed the sum of £4,000 to the Royal Society, as well as similar amounts to the Institution of Electrical Engineers, London, and the Académie des Science, Paris. No restriction of age or nationality was to weigh in the selection of any recipients.

Dr. Bell was born in Edinburgh, Scotland, March 3rd, 1847, son of Alexander Melville Bell, who, in 1870, became a lecturer on philology at Queen's College, Kingston, Ontario, removing in 1881 to Washington, D. C., where he devoted himself to the education of deaf mutes. Graham Bell was educated at Edinburgh University and London University. Going with his father to Canada in 1870, he, two years later, was appointed a professor of vocal physiology in the Boston University.

Bell for many years was Regent of the Smithsonian Institution in Washington. He has taken an active interest in phonetics, and has invented a machine called the graphophone, allied to the phonograph, for recording and reproducing sound. This instrument has come into use for teaching phonetics in American schools and colleges. In his later years he has experimented on the problem of flying, and has invented special types of man-lifting kites. His inventions and experiments have shown much originality and his scientific contributions, especially to applied science, have great merit.

The tribute paid by the late Sir William Preece, F.R.S., to Bell's services may here be recalled. Writing in 1878, he said: "The phonograph is the outcome of the articulating telephone. Though several have added their share in perfecting the 'far-speaker,' there is no name in connection with it that will shine with greater brilliancy than that of Alexander Graham Bell. His father's occupation as a vocal physiologist, led him to study the vocal organs and the production of sound. Helmholtz's researches led him to investigate electricity and its application to telegraphy. The desire to increase the capacity of wires for the conveyance of messages led him to devise systems of multiple telegraphy, and this by steady and sensible degrees, led him to articulate telephony. We have a notable example of the modern method of research, where imagination suggests experiment, and experiment by evolution produces growth and perfection. The telephone will always be associated with Bell's name, and it will remain one of the marvels of this marvelous age, while its chief marvel will be its beautiful and exquisite simplicity."

The Glow of Sulphur*

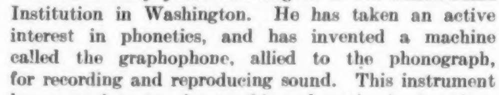
By W. H. Watson

Although not mentioned in the majority of textbooks, the fact that sulphur under certain circumstances exhibits a glow or "phosphorescence" has been frequently recorded. The method of obtaining the glow was described by Berzelius in his "Lehrbuch" (5th edition, vol. i., p. 185), and since then several investigators have turned their attention to the matter, but without arriving at an explanation of the phenomenon. The idea has been suggested that the glow was accompanied by the formation of a lower oxide of sulphur, possibly a monoxide, SO, but attempts to obtain such a body by Heumann (*Ber.* xvi., 139), O. Jacobsen (*Ber.* xvi., 478), and also by the writer, have proved unsuccessful. Experiments upon the oxidation of sulphur at low temperatures by Moissan (*Comptes Rendus*, 1903, xxxvii., 547) also lend no support to the idea. At the suggestion of Prof. H. B. Baker, to whom the writer desires to express his indebtedness, a further investigation of the phenomenon was undertaken with the results set forth below.

In the paper by Heumann referred to above, the author describes various methods of obtaining the glow, the most successful of which appears to be that of placing sulphur on a shallow tray supported above the bottom of an iron air-bath heated to about 240 degrees, and allowing a current of air to pass over the molten sulphur. When the conditions are properly regulated, a large flame, differing in color from the usual blue flame of burning sulphur and also in the fact that it is relatively cold (see also Baker, *Journ. Chem. Soc. Trans.*, 1900, lxxvii., 646), can be obtained and maintained for a considerable time. The author states that the slow combustion is accompanied by a curious smell which he compares to ozone or camphor.

These facts have been confirmed by the present writer, who found that the glow invariably exhibited itself as a curious luminous flicker over the heated base and adjacent parts of the sides of the oven, but never on the surface of the sulphur. Further experiments were made by means of an apparatus similar to that described below.

A piece of glass tubing, 40 to 50 centimeters long and about 1 centimeter bore, was bent as shown in the sketch, and had a narrow side-tube sealed in at *C*. Some pure re-crystallized sulphur, which had previously been kept melted for some time, was placed in the part *A*, while *B* was inclosed in an air-bath kept at 100 to 120 deg. Cent. The sulphur was maintained at about 250 degrees, while a slow current of pure dry air was passed through the apparatus, the side-tube *C* being closed. So long as the sulphur was kept below its ignition-point, no luminosity could be observed on the surface of the sulphur, but the air current became charged with a cloud of fine particles which were carried along the tube and not completely deposited before reaching the open end. In the portion of the tube within the air-bath, extending for some centimeters from the end nearer the melted sulphur, a steady glow could be observed, which, however, ceased if by any chance the liquid sulphur became ignited. The glow could be produced at any part of the tube *B* by heating gently at that part and allowing the rest to remain cool, even when *B* was of considerable length. By using a mixture of nitrogen and air a somewhat brighter glow was obtained, but the glow completely ceased if pure nitrogen were employed. In this latter case, however, it was possible to obtain a glow by introducing air through the side-tube *C*. It would therefore seem unlikely that the glow is connected with a preliminary action of oxygen on the heated sulphur.



If the air current after passing over the heated sulphur were filtered through a tube filled with recently ignited asbestos no glow whatever could be obtained in *B*, but the glow reappeared when the asbestos was removed. Similar results were obtained if cotton-wool or pieces of moist stick potash were used instead of asbestos. Bubbling the air through water was also effective, and a quantity of colloidal sulphur collected in the water.

In another series of experiments the gases escaping from the end of the tube in which the glow was taking place were led through a tube immersed in liquid air. A small amount of solid sulphur dioxide was collected, and in some cases a liquid. This latter, however, contained no sulphur compound other than a trace of sulphur dioxide, as on careful evaporation and bubbling the resulting gas through fuming nitric acid or a solution of potassium permanganate, no sulphuric acid was obtained. The gas contained about 40 per cent of free oxygen, and the residue appeared to be nitrogen and probably some argon. Similar results were obtained if the gases immediately after leaving the heated sulphur, and without allowing the glow to occur, were treated in the same way. In all cases the gas which escaped liquefaction by the liquid air was quite odorless.

There is therefore no direct evidence that an appreciable amount of an oxide of sulphur other than dioxide is formed at any stage. Heumann arrived at a similar conclusion from an analysis of the gases escaping from glowing sulphur. The glow appears to be caused by the oxidation of the particles of finely-divided sulphur resulting from the cooling of the air which has passed over the heated sulphur, and this view is in harmony with the observations recorded both here and in the records of earlier investigators. If this finely-divided sulphur is the result of some such reactions as the following — $2S + O_2 = 2SO$, then $2SO = SO_2 + S$, the intermediate product must have a merely transient existence, and its presence would not be shown by chemical tests.

The finely-divided sulphur not only undergoes oxidation at a comparatively low temperature, but attacks copper and silver at the ordinary temperature with the production of black films of sulphide. Experiments made in order to discover whether the particles were electrified or not, failed to show the existence of a charge. Air containing the finely-divided sulphur led through a tube containing an insulated piece of copper-foil connected with a delicate electroscope did not discharge the latter, whether the instrument carried a positive or negative charge. In other experiments the stream of finely-divided sulphur passed between two long strips of platinum foil, insulated and connected to opposite terminals of a small induction coil. Some 5 to 10 milligrammes of sulphur deposited on the plates in the course of an hour, but although the amounts deposited on the two plates were generally unequal, the variation was not large, and, moreover, not constant. On the whole, the results obtained were not decisive.

Summarizing the results obtained, it may therefore be stated that when air passes over sulphur heated to a temperature below its ignition-point, the air becomes charged with sulphur vapor, which, as the temperature falls, separates as a mist or cloud of very small particles. The oxidation of this finely-divided sulphur gives rise to the phenomenon of the glow or "phosphorescence," but there is no evidence that at any stage any other oxide than sulphur dioxide is formed.

*Reproduced from the *Chemical News.*

Indian Corn in the Far East

Consul General Anderson, stationed at Hong Kong, calls attention to an economic change of the utmost importance now in progress in the Far East, viz., the introduction of maize as a formidable competitor of the hitherto universal rice. Indo-China and the Philippines have already developed the cultivation of this grain to an extent which has affected international trade in the East and resulted in great benefit to the peoples concerned. Maize has made less rapid progress in China. The cultivation of maize in the Philippines results from an energetic campaign of education on the part of the Bureau of Agriculture. In most parts of the islands two or even three crops can be produced annually. The recent threatened rice famine in the Philippines, which impelled the government to import large quantities of rice and sell it below cost, emphasizes the urgent need of a diversification of the native diet.

Report on Investigation of Grinding Wheel Protection Devices*

Hoods and Flanges

By R. G. Williams

Wheel: 24 by $2\frac{1}{2}$ by $1\frac{3}{4}$ inches, tapered $\frac{3}{4}$ inch to the foot, alundum 14-0 vitrified; speed, 6,000 surface feet. Flanges: Steel, 20 inches in diameter, relieved, tapered $\frac{3}{4}$ inch to the foot. All segments were retained by flanges. Compare this with the views on the page opposite, showing tests on grinding wheels fitted with flanges only 12 and 14 inches in diameter, and where a large portion of the stone escaped from the flanges.

Wheels: 24 by $2\frac{1}{2}$ by $1\frac{3}{4}$ inches, tapered $\frac{3}{4}$ inch to the foot, alundum 14-0 vitrified; speed, 6,000 surface feet. Flanges: Steel, 20 inches in diameter, relieved, tapered $\frac{3}{4}$ inch to the foot. It should be noted that while only 2 inches of the wheel projected beyond the flanges it was possible to break off a portion of the projecting mass. Thus, the operator would be in more or less danger from these broken pieces.

Recent discussions in the technical press and publications devoted to industrial safety and welfare work have forcibly brought to the attention of those most interested the fact that there is no uniformity or standardization of grinding-wheel protection devices. This lack of uniformity has been a serious handicap in the development of safer manufacturing conditions. Attention has also been drawn to the fact that there were no recorded data or observations on which standardization and safety rules could be based. With the purpose of obtaining data and observations on the relative protection offered by an approved type of protection hood and approved beveled steel flanges, a series of tests, described below, was conducted in the research laboratories of a large firm of grinding-wheel manufacturers.

The testing equipment consisted of an up-to-date grinding-wheel stand driven by a $7\frac{1}{2}$ horse-power gasoline engine. A wooden frame work of heavy timbers was built over the side on which the flanges were tested, to intercept pieces of the wheels which might possibly break off outside the flanges.

In all the tests the wheels were operated at 6,000 peripheral feet per minute, the speed being very carefully regulated immediately before each test.

HOOD TESTS.

The wheels used for the hood tests were 16 by 2 by $1\frac{3}{4}$ inches alundum vitrified of various grains and grades and had parallel sides. The hood was of modern type, and the wheels were mounted between relieved 8-inch diameter cast iron flanges. One layer of blotting paper of standard thickness was used between the wheel and each flange. The nut on the spindle was not tightened excessively, but drawn up enough to firmly hold the wheel.

The wheels in the hood tests were broken by dropping a steel wedge between the rest and the side of the wheel in such a manner as to provide a severe blow. The object was to duplicate as near as possible one of the most frequent causes of accident, that of the work being caught between the rest and the wheel.

FLANGE TESTS.

The wheels used were all 24 by $2\frac{1}{2}$ by $1\frac{3}{4}$ inches alundum vitrified grain 14, grade 0, tapered both sides, $\frac{3}{4}$ inch to the foot, with a flat at the center of 4 inches diameter. One thickness of standard blotting paper was used between the wheel and each flange. In these tests, five sets of relieved steel flanges tapered $\frac{3}{4}$ inch to the foot were used, of 12-inch, 14-inch, 16-inch 18-inch and 20-inch diameter.

The wheels in these tests were broken by swinging a 130-pound cast iron weight against the side of the wheel. This method of breakage corresponds to a common cause of accident when heavy castings, which are suspended by tackle above the wheel, are carelessly allowed to strike the side of the wheel with enough force to cause breakage.

(The manner in which a wheel is broken is not important when protection devices for grinding wheels are being studied, so even though the wheels were broken by different methods in the hood tests and the flange tests, the results obtained are comparative from the point of view of protection to an operator.)

OBSERVATIONS.

1. In none of the hood tests did a piece of the wheel leave the hood in a way that could have caused damage. The tests show conclusively that a well designed protection hood, made of the right material, and properly adjusted, affords ample protection for straight side wheels even when they are mounted between standard straight relieved flanges one half the diameter of the wheel.

2. It is possible to break pieces from a wheel by a severe blow when there is only 2 inches of the wheel projecting beyond the flanges. With protection flanges, no matter how little the wheel projects beyond the flanges, an operator has no protection from injury in case a piece of the wheel breaks off outside of the flanges, whereas with a hood, protection is almost absolute.

DISCUSSION.

1. It was not the intention to obtain data from which standard specifications for hoods and flanges could be drawn; nevertheless, the tests as a whole brought out a number of points which could be so used.

2. If specifications for hoods for rough grinding are drawn, they should not only require a certain strength as determined by the design and material used, but they should also require that the top end of hoods have some sliding-tongue device, which can be adjusted as the grinding wheel wears, and thus offer at all times the maximum protection possible. They should also contain a definite statement as to the maximum exposed grinding surface allowable for the common varieties of grinding. For example: Can 60 degrees, 70 degrees or 80 degrees of grinding surface be exposed on the type of machine known as the floor stand? Such specifications should also state the minimum size wheel allowable in a hood of given dimensions.

3. In a majority of instances where protection flanges are now used, ample protection can be obtained by means of hoods without such flanges. However, there are conditions where a hood is not practical and where flanges offer the next best method of protection.

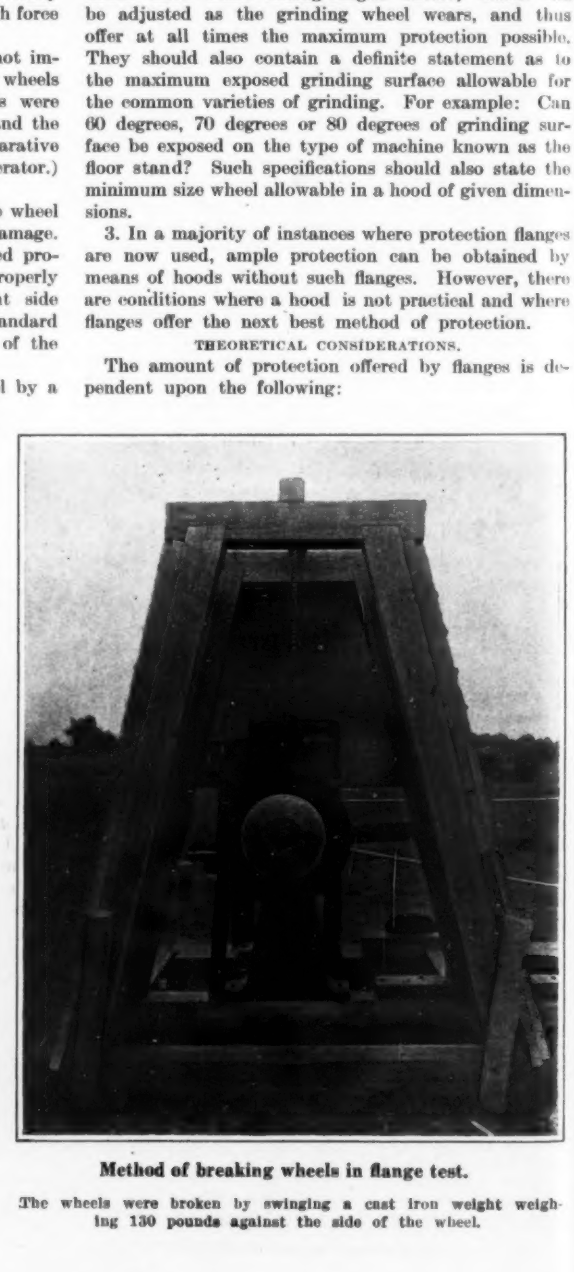
THEORETICAL CONSIDERATIONS.

The amount of protection offered by flanges is dependent upon the following:

* Paper read before the American Society of Mechanical Engineers.

Equipment used in the tests here described.

Machine: A $1\frac{3}{4}$-inch floor stand wheel—a type of very recent design—heavy, rigid, and operated at a speed of 6,000 surface feet per minute for all tests. Power: $7\frac{1}{2}$ horse-power gasoline engine.



Method of breaking wheels in flange test.

The wheels were broken by swinging a cast iron weight weighing 130 pounds against the side of the wheel.

A—The ability of the flanges to resist wedging action of a broken piece of the wheel.
B—The size of the flanges.
C—Bevel of the wheel.
D—Peripheral velocity of the wheel.
E—Mass of the wheel.
F—Degree of safety.

Degree of safety, as here used, expresses the relationship between the thickness of the wheel at the hub and the thickness of the wheel at the point where the outer edge of the flanges bear on the wheel. In other words, it is an expression which indicates how much

Wheel: 24 by 2½ by 1¾ inches, tapered ¾ inch to the foot, alundum 14-0 vitrified; speed, 6,000 surface feet. Flanges: Steel, 12 inches diameter, relieved, tapered ¾ inch to the foot. The wheel broke into 42 pieces of various sizes. Approximately two thirds of the wheel escaped from the flanges.

the flanges must spread in order to let out a broken sector of the wheel.

1. If the force with which a sector tends to come out of protection flanges is great enough to spread the flanges, a distance of minus *B* inches (see sketch), then a sufficient amount of protection is not present. Sufficient protection can be obtained by (a) increasing the thickness of the flanges, (b) using flanges of a material with a greater modulus of elasticity, (c) increasing the diameter of the flanges, or (d) increasing the taper per foot of the wheel.

Some figures obtained from the 16-inch diameter flange test give a basis on which standard specifications may be formulated. The combination of factors present in this case resulted in what could be termed a critical condition.

The wheel broke into four almost equal pieces, the weights of which were about 23½ pounds. The peripheral velocity of the wheel was 6,000 feet per minute. The wheel was tapered ¾ inch to the foot, the taper ending 2 inches from the center of the wheel. In order for a sector to fly out of the 16-inch diameter flanges, the flanges had to spread a total of ¾ inch. After the breakage, it was found that the sectors had moved out a little over 5½ inches and the flanges had spread a little over 11/16 inch or nearly the required distance to let out the sectors.

The shape of the flanges used was such that it has been found impractical to consider them as cantilevers of the same cross sectional area, and therefore, the acting forces in the above case and the exact factor of safety cannot be readily calculated. For this reason we cannot deduce definite formula relations between the several factors involved. We can, however, find a proportional relation which expresses the relative degree of safety with different size wheels and flanges.

2. Twenty-inch diameter flanges must open 1 inch

Wheels: Two 18 by 1¼ by 1⅝ inches, alundum 20-0 vitrified; speed, 6,000 surface feet. The wheels were both mounted at the same time and separated by three blotters. In this test, it was attempted to cause breakage by dropping various metallic objects such as nuts, bolts, and wedges between the rest and the face of the wheel. After several unsuccessful attempts the wheels were gouged to the depth of 1½ inches and the same breaking process employed. It was not possible to break the wheels in this manner. Breakage was finally caused by dropping a wedge between the rest and the side of the wheel. None of the broken pieces escaped from the hood.

to let out a sector. This distance is 33⅓ per cent more than in the case cited above, so that 20-inch flanges of the same stiffness as the 16-inch flanges would just about hold the quarter sector of a wheel of 33⅓ per cent greater mass. A 24-inch wheel of 33⅓ per cent more mass than the 24 by 2½-inch wheel cited above would be a wheel about 24 by 3⅜ inches.

Since 20-inch flanges are as large as is practical to use on wheels 24 inches in diameter, it is quite obvious that 24-inch wheels of a thickness greater than 3½ inches are not safely guarded by means of ¾-inch

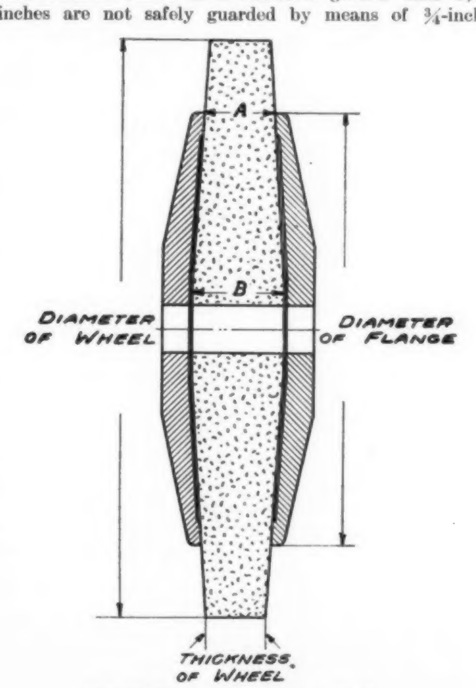


Diagram showing method of mounting grinding wheel in flanges.

taper protection flanges, unless the flanges are made more rigid than most of the existing type of flanges.

3. Standard specifications should require a factor of safety of at least two. This requires a greater taper than ¾-inch to the foot, or the use of very heavy steel flanges.

CONCLUSIONS.

1. The protection offered by any given taper decreases with decreased diameter of the wheel. To provide equal safety on all sizes of wheels would require, therefore, a graduated difference in taper.

2. A hood with adjustable tongue furnishes equal pro-

Wheel: 24 by 2½ by 1¾ inches, tapered ¾ of an inch to the foot, alundum 14-0 vitrified; speed, 6,000 surface feet. Flanges: Steel, 14-inch diameter, relieved, tapered ¾ inch to the foot. This wheel did not break into as many pieces as the wheel in the 12-inch flanges. Approximately three quarters of the wheel escaped the flanges.

tection for a wide range in the diameter of the wheel.

3. Second to safety, the cost of operating a given grinding machine is of vital interest. In this respect adjustable hoods have the better of the argument, for, as the wheel wears, protection flanges must be changed frequently. Such change involves the removal and remounting of the two flanges and wheel, whereas in the case of a hood the change would merely involve set screw adjustment.

4. To provide adequate protection for wheels 3 inches and thicker the thickness (hence the weight) of flanges would have to be decreased beyond those of any flange now on the market. This would mean added momentum to the revolving spindle, which in turn would require greater rigidity and strength than is to be found in the large majority of present-day grinding machines.

5. Since the face of a tapered wheel becomes wider as the diameter increases, serious inconvenience is caused in all grinding where the wheel must work in a slot.

6. Tapered wheels do not permit the grinding of right angle shoulders as do straight wheels.

7. Laws in almost every country require the removal of dust from grinding. This requires the use of a hood, and if a hood must be used, it might just as well be strong enough to offer protection in case of accident.

8. A proper hood offers complete protection. Protection flanges cannot offer this complete protection, but in instances where a hood would interfere with the proper use of the wheel, flanges offer the next best method of protection.

Tracing Through Opaque Paper*

Every engineer has occasion to trace or copy a map, plan or other drawing on paper too thick for the ordinary way of using tracing cloth or tracing-paper. When the figure is small and simple, a copy may be made by holding the original against a window pane, covering it with the paper, and tracing directly by the aid of the strong sunlight from outside. The need of utilizing this principle on a larger scale and in a more convenient position led Dr. J. C. Branner to plan the table of which a description follows.

This table was first made in the form of an adjustable glass-top table with a mirror beneath, in 1887, while Dr. Branner was State Geologist of Arkansas. Later it was modified as experience suggested until the form here described was evolved.

The device consists essentially of a drafting-table with a plate-glass top, upon which the original drawing and the paper are laid, and a mirror underneath to reflect the light of the sky up through the drawing. The glass top is hinged and fitted with two arms and thumbscrews, so that it can be raised and fixed in any position, either inclined or horizontal. The mirror is pivoted and revolves about a horizontal axis, so that it may be tilted to any angle. The hood of cardboard or black cloth prevents the reflection of light from the tracing, and may or may not be attached to the table.

The apparatus is set up before a window through which part of the unobstructed sky is visible. The mirror is then adjusted like the reflector of a miscroscope, so that the skylight is reflected through the drawing. If the mirror can be so located that the direct rays of the sun are reflected through the drawings, thicker paper can be used.

The map or drawing may be held in place by clips screwed to the top of the plate-glass frame or by lead weights placed on top of it.

The dimensions may be varied to suit individual needs. An important point to be remembered in the construction is that the piece at the back should be made as narrow as possible so as not to shut out more light than necessary. The frame of the glass top also should be made narrow at the top for the same reason.

This table can be used at night by employing an electric light, so placed as to be reflected or even to shine directly up through the plate-glass table-top.

It sometimes happens that the light from beneath is inconveniently strong, but this objection can be obviated by cutting a small opening in a piece of thick or dark paper which is laid over the drawing. The tracing can then be done through the hole, and the sheet can be moved about at pleasure, which gives the advantage also of preventing the tracing from being soiled, and it often brings out more clearly the lines to be traced.

* Contributed by M. A. T. Schwennesen, of Stanford University, Cal., to Bulletin 53 of the American Institute of Mining Engineers.

Dynamo-Electric Lighting for Automobiles*

Automatic Control of Output at Varying Speeds of Machine

By Alfred E. Waller

Dynamo-lighting equipments on motor-cars are required to maintain at all times a supply of electric energy sufficient for proper road-lighting. It is therefore natural, in the design of such apparatus, to decide first what may be accepted as a satisfactory set of lamps for motor-car use. When this point has been determined, the capacity of dynamo, battery, and auxiliary apparatus may be readily deduced. The choice of lamps is influenced by a great many considerations, and among these is the variable element of individual preference. Some drivers prefer to have a good deal of light near the car; others insist upon lamps which will project the light a considerable distance ahead, and leave objects close at hand in comparative darkness. Many arguments are offered in favor of each type, and, in order to have his product meet with general favor, a lamp-designer must take both extremes into account. A great deal of interesting experimental work has been done with headlights, of both American and foreign design, in order to determine the characteristics of the most suitable lamp and reflector. As a result, the 21 candle-power 6-volt tungsten lamp has been adopted for use with a parabolic reflector measuring 10 inches (25.4 centimeters) across the opening. This choice was governed by several considerations In the first place, it was shown that with lamps of this description a road 50 feet (15.2 meters) wide could be perfectly lighted for a distance of at least 1,000 feet (304.8 meters) in advance of the car. Objects on the road could be distinguished practically as far away as would be possible in daylight, and always in ample time to stop or turn aside, as the case rendered necessary. In the second place, 10 inches (25.4 centimeters) reflectors were used because they did not necessitate extremely large headlights, which, besides being costly, would detract from the appearance of a motor-car. The importance of having lamps properly focussed was brought out in these experiments. For the best results, the lamp-filament must be located exactly at the focus of the parabolic reflector, and the reflector should be so designed that the focus is well back from the opening. A comparatively deep reflector makes the angle of the direct rays not intercepted by it rather small; consequently, a greater proportion of the total candle-power may be projected in a useful direction. The effect is particularly good when the lights are placed at least 3 feet (0.9 meter) from the ground. At this height the shadows caused by slight ridges and undulations in the road are not so apparent as when the lights are placed lower. The 10 inches (25.4 centimeters) parabolic reflector adopted measures about 5½ inches. (14 centimeters) in depth. This reflector has a focus of 1 1-8 inch (2.85 centimeters), and, when properly focused, a 21 candle-power lamp gives ample light on the road near the car, and at the same time has very good distance qualities. Very deep reflectors, both of the 8 inches (20.3 centimeters) and 10 inches (25.4 centimeters) diameter sizes, were tried; but it was found that these did not give satisfactory lighting near the car. Twenty-four candle-power lamps were tried out in the 10 inches (25.4 centimeters) reflector, but the difference in illumination was scarcely noticeable, and was more than offset by the fact that the 24 candle-power lamps required 14 per cent more current than the 21 candle-power. The side and rear lights, which are used only as signal lights, and have little value for road-lighting purposes, were equipped with 4 candle-power and 2 candle-power lamps respectively. Lights of lower candle-power than this would have been ample for the purpose; but in the smaller sizes of lamps the filaments were found to be too frail to give reliable service under the conditions of severe vibration encountered on a motor-car.

Considering, therefore, that a proper equipment consists of a pair of 21 candle-power headlights, a pair of 4 candle-power side-lights, and a 2 candle-power rear-light, we find the current taken by these lamps to be 7 amperes, 1.7 amperes, and 0.6 amperes respectively, making a total load of 9.3 amperes at 6 volts. In addition to this equipment, we find on the average car an electric horn and a speedometer light; but as these devices are used only intermittently their current is not an important factor in determining the maximum dynamo capacity which will be required.

Allowing for the intermittent use of the speedometer light and electric horn, it is evident, from the figures quoted above, that an adequate lighting dynamo must have an output of 10 amperes, in order to maintain at all times a sufficient supply of energy. Further, as the dynamo is available as a source of energy only when the motor-car engine is running, a battery must be provided to furnish current when the engine is at rest. A three-cell lead battery has been universally adopted for use with 6-volt lights, and the dynamo must therefore be capable of furnishing 10 amperes at a voltage sufficient to charge a battery of this type.

Our next consideration is the car speed at which the full load output of the dynamo must be delivered. Much of the mileage covered by the average motorist is traversed at a speed of not more than 18 miles per hour, and if we are to reserve the storage battery for use when the motor-car engine is not running, our dynamo must be so geared that it will carry the entire light-load when the car is traveling at this speed or above. If the speed falls below, say 18 miles per hour, more or less current will be drawn from the battery, as the dynamo will not be generating its full capacity. A great deal of night driving at slow speed with all lights on, would in time run down the storage battery; but it is found in practice that little slow-speed running is done with all lights on. In the city where this condition does prevail to a large extent, the headlights are not as a rule in use, and the load taken by the remainder of the equipment is readily supplied by the dynamo. Further, if the car is used in the daytime at all, the charge accumulated by this running serves to keep the battery always charged and in perfect condition. If cars are left standing, the headlights are, of course, turned off, and the 2.3 ampere load represented by the side and rear light may be carried for some time upon a proper battery. The ideal electric lighting system is entirely automatic. Means must be provided for connecting the dynamo to the battery when speed proper for charging has been reached, and for disconnecting the dynamo from the battery when the speed is reduced to a point where a reversal of current is about to take place. This is a feature which is present in all properly-designed lighting systems. In some systems now on the market, the connecting and disconnecting from the battery is accomplished by a centrifugally-operated switch. The dynamo speed, which corresponds to a correct voltage for charging, is predetermined, and the centrifugal device is set to close the circuit at this time, and to open it as soon as the speed is reduced below the safe point. In most cases, however, the operation is accomplished by means of an electro-magnetic switch. This switch, or relay, as commonly constructed, has two windings, one of high resistance, which is permanently connected across the armature terminals. The relay is set so that it closes the circuit between the dynamo and the battery, when energized by a potential sufficient for charging the battery, and opens the circuit when the dynamo voltage is reduced below this point. As a precautionary measure, a series winding is placed upon the relay with the shunt winding. This series winding reinforces the shunt winding while charging is going on, but bucks it upon reversal of current, thus tending to produce complete demagnetization of the relay.

One of the most important functions of the automatic-lighting system is the control of the dynamo output at the very high speeds reached by motor-car engines. It will be readily understood that if a dynamo is arranged so that it is driven at, say, 1,000 revolutions per minute, at a car speed of 20 miles (32 kilometers) per hour, and is delivering its full output at this speed, when the car speed has been increased to 40 miles (64.3 kilometers) or even 60 miles (96.5 kilometers) per hour, a dynamo not properly protected will be forced to generate current far in excess of its rated capacity, and a burn-out will inevitably result. No matter what type of dynamo used, there must be some means of compensating for the current fluctuations which occur with speed changes. As in the case of the automatic switch for connecting to the battery, the more difficult problem of controlling dynamo output has been accomplished by means of both mechanical and electrical devices. It is my intention in this paper merely to describe a number of regulators which are now widely used without commenting either favorably or unfavorably upon their respective merits.

Considering first the mechanical types of control, we have slipping clutches of different designs. For example, one manufacturer uses a clutch composed of two members, one of which is rigidly attached to the dynamo shaft, and the other to some convenient drive shaft. The clutch members are held together by spring pressure, and, as the speed of the driving member increases, this spring pressure is neutralized by means of centrifugal governors, which oppose the spring tension, and allow slippage between the clutch members, the amount of slippage depending upon the speed of the driving member. This allows the dynamo to be driven at a substantially constant speed, regardless of that of the motor-car. The regulator adopted by another manufacturer has in it a centrifugal governor which turns at the same speed as the dynamo, and moves a small contact arm over a number of steps of resistance inserted in the field circuit of the dynamo. The greater the dynamo speed, the more resistance is inserted with the field, so that a substantially constant output is obtained. There is a much larger number of electrical devices for this purpose. One of the earliest consisted of a resistance made of small carbon disks arranged in a tube, and connected in series with the dynamo field winding. The disks are normally pressed very tightly together by a spring, and in this condition have a low electrical resistance. The device is so arranged that the armature current of the dynamo passes through a series coil, which is arranged to pull directly against the spring which compresses the carbon discs. Consequently, when excessive charging rates are reached, the pull of the series coil tends to neutralize the spring pressure upon the carbon disks, and the resistance of the field circuit is increased by the release of pressure.

One method which is much used with the permanent field type of dynamo is to design a machine with high armature reactions, and to depend upon these to prevent excessive generation of current. Compound windings have been successfully used with both bipolar and multipolar dynamos for this work, in spite of the very great range of speed encountered. Other manufacturers have used double field windings, one portion arranged to oppose the flux generated by the other portion. These opposing or bucking coils are thrown into play at the proper moment by a series relay inserted in the armature circuit. One magneto-type dynamo manufactured has a permanent field with auxiliary electro-magnetic field windings, which are disconnected when a certain current has been reached. If the speed is increased beyond this point, the auxiliary electro-magnetic fields are again brought into play and are energized so as to oppose the flux of the permanent field. This gives a very wide range of regulation. In several cases, modifications of the controls described above have been used by regulating the dynamo for a certain maximum voltage instead of maximum current. In another lighting system, regulation is accomplished by the introduction of a coil of iron wire in the armature circuit. This coil has the property of increasing resistance very slowly, until a certain critical current is reached, and then increasing at a very rapid rate to several times its original resistance. The terminals of a bucking field coil are connected across this series coil of iron wire, which is so designed that the critical point where its resistance increases rapidly is reached when the maximum dynamo current is being generated. Normally the potential difference applied to the terminals of the bucking coil is negligible; but when the iron wire has become sufficiently heated, this potential difference becomes sufficient to generate a considerable flux in the bucking coil, and to reduce materially the output of the dynamo.

Among the devices designed to secure constant dynamo output at varying speeds, are several foreign inventions. In one of these a bipolar shunt-wound dynamo is arranged with a pair of auxiliary poles placed between the main poles of the machine. The auxiliary poles are not wound, but are excited by the cross-magnetization caused by the working current in the dynamo armature. Two brushes are placed in the neutral position relative to the main poles, and are sufficiently wide to short-circuit several armature coils during the period of commutation. When the armature is revolved, the dynamo behaves as an ordinary shunt-wound machine, except that the load current in the armature conductors, by virtue of its cross-magnetizing ampere turns, sets up a flux in the auxiliary unwound poles provided to receive it. The armature coils short-circuited by the brushes cut this cross-flux, and, consequently, have a short-circuit current induced in them, which is proportional to the cross-flux and to the speed of rotation. This short-circuited current acts in such a direction as to demagnetize the main wound poles. In this manner the voltage of the dynamo is regulated so as to compensate for speed changes, and also for load changes. One foreign manufacturer has designed a distributing panel, in which each circuit on the car has a properly proportional coil of resistance-wire in series with it. This wire is of such

* A paper presented at the 288th meeting of the American Institute of Electrical Engineers, New York.

gage and length that it permits a certain amount of current to flow in the circuit, this being predetermined, and increases in resistance to eight or ten times its nominal value when this current value is exceeded, thus protecting the lamps against burn-out. In a well-known French design a bipolar dynamo is used, with two windings on each pole, the pairs being wound to produce magnetization in the same direction. One side of each of the four coils is connected to the negative brush of the dynamo, and the four remaining terminals are connected to the positive brush through four small breakers arranged concentrically around the dynamo shaft. These breakers are opened in succession by a cam on the end of the dynamo shaft, and only one breaker is opened at a time. At slow speeds, the effect produced by opening momentarily one of the four field-coils, and closing it again before opening another, is negligible; but as the speed is increased, the interruptions become so rapid that the dynamo field does not have time to build up to its full intensity, and constant output may be secured from the dynamo over a wide speed range. In the particular lighting system under consideration, a plain shunt-wound dynamo was adopted, as being the simplest and most reliable type, and a system of control was developed which gives perfectly satisfactory regulation. The necessary regulation is secured by means of a single step of resistance inserted in series with the dynamo field. This resistance, which is of such a value that it will limit the dynamo output to its predetermined maximum at the highest car-speed obtainable, is normally short-circuited; but the short-circuit is removed from the resistance when the maximum charging current has been reached. This is accomplished by means of a relay, the coils of which carry the armature current. In practice, the short-circuit is removed from the resistance in series with the dynamo field when a current of 10.1 amperes has been reached, and when this resistance is thus inserted in the field circuit, the dynamo output immediately falls off. When the current is reduced to 9.9 amperes, the resistance is once more short-circuited, and, as the interval of time required for this change in current is very short, an extremely rapid vibration of the relay contact is set up, and a substantially constant current is obtained over a wide range of speed. In the early experimenting, a relay of the familiar telegraph type was used; but lengthy experiments led to the adoption of a modified type in which the trunnions or pivots are replaced by a flexible phosphor-bronze hinge of suitable gage and width. This construction is found to be highly satisfactory, and is not affected by vibration.

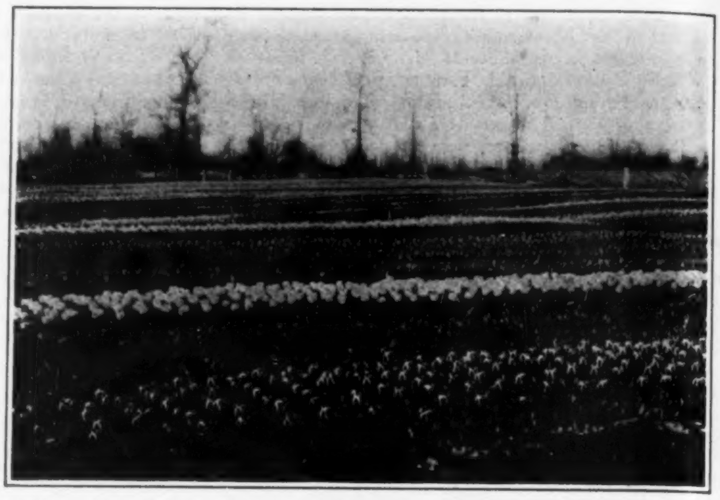
There are a number of other systems of control which are quite as efficient and well known as those I have mentioned, and a great deal of time might be devoted to their discussion and comparison. It is necessary at this time, however, to consider the initial speed at which a dynamo should be designed to give its full output. This is an important consideration, and is so closely related to the construction of the motor-car engine with which the system is to be used, that the general arrangement of the engine must be carefully taken into account. It is well known that the size, weight, and cost of a dynamo of any particular type depends not only upon the watt output, but also upon the speed at which this output is delivered. Consider as an example the shunt-wound dynamo. One which will deliver 7.5 volts and 10 amperes at 1,500 revolutions per minute costs 30 per cent less than one which will deliver the same output at 1,000 revolutions per minute, and less than half as much as one designed for a speed of 500 revolutions per minute. The weights of the respective machines are in approximately the same ratio as their cost. A shunt-wound dynamo designed for the stated output at approximately 1,000 revolutions per minute weighs about 21 pounds (9.5 kilogrammes), and can be made approximately 8 inches (20.3 centimeters) long by 5⅝ inches (13.2 centimeters) high by 4¾ inches (12 centimeters) wide. If it is required to secure the same output at 500 revolutions per minute, the weight must be increased to approximately 35 pounds (15.8 kilogrammes), and the dimensions become 9¼ inches (23.5 centimeters) by 7⅛ inches (18 centimeters) by 4¾ inches (12 centimeters) approximately. On the average four-cylinder motor-car, a 1,000-revolution dynamo is run at about twice engine-speed for the best results, and the 500-revolution dynamo should be run at engine-speed. Bearing these facts in mind, the selection of a dynamo for any particular automobile engine becomes a matter of judgment, and must be largely governed by the structure and arrangement of the engine itself. Speaking broadly, it will be found that when a 500-revolution-per-minute dynamo may be readily coupled to a shaft which runs at engine-speed, its extra weight and cost are justified by the fact that it renders sprockets and chain or gears, and their care, unnecessary. On motors where an installation of this type entails the extension of a shaft not readily accessible, or the use of a countershaft or an idler gear, or some other device for bringing the direct drive into a convenient location, a chain-driven dynamo, geared to run at twice engine-speed, may be used to advantage. Where a geared dynamo is necessary, the shunt-wound machine designed to deliver its output at 1,000 revolutions per minute, and driven at approximately twice engine-speed, appears to be the most advantageous design in weight, cost, and size. Such a dynamo, when driven at twice engine-speed on a car with 36-inch (0.9 millimeter) rear wheels, geared 3½ to 1 on the back axle, will start charging the battery at from six to seven miles (9.6 to 11.2 kilometers) per hour, and will deliver its full output of 10 amperes at about 15 miles (24.1 kilometers) per hour. The same dynamo on a car geared 3 to 1 with 36-inch (0.9 millimeter) rear wheels, would begin to charge the battery at approximately 9 miles (14.4 kilometers) per hour, and will balance the lamp-load at approximately 18 miles (28.9 kilometers) per hour. A machine of this type has distinct points of advantage over a dynamo designed to deliver its output at either a higher or a lower speed. Considering first a higher-speed dynamo, let us assume a rated speed of 1,500 revolutions per minute for full output. This dynamo is smaller, lighter, and cheaper than a dynamo designed for 1,000 revolutions per minute, but must be driven at approximately three times engine-speed. In practice, if a ⅜-inch (9.5 millimeters) pitch silent chain is used, the driven and driving sprockets will have 15 and 45 teeth, respectively. This means a chain speed of 2,250 feet (685.8 meters) per minute at 45 miles (72.4 kilometers) per hour of the car, and 3,000 feet (914.4 meters) per minute at 60 miles (96.5 kilometers) per hour. These speeds are too high for best results, and cause rapid wear of the chain. It should be noted also that the chain is likely to become noisy when driven at this speed. On the other hand, a dynamo driven at less than twice engine-speed, in order to secure lower chain-speed, and less wear on the bearings, is not an advantageous arrangement. The cost and weight of the dynamo are immediately increased without the elimination of sprockets. It becomes evident, therefore, that if the chain-speed reached by the drive of the 1,000-revolution-per-minute dynamo is not excessive, it has a decided advantage over either of the types just mentioned. Investigation shows that in practice sprockets of 30 and 15 teeth would be used with ⅜-inch (9.5 millimeters) pitch silent chain, and at 45 miles (72.4 kilometers) per hour the chain-speed would be 1,500 feet (457.2 meters) per minute, and at 60 miles (96.5 kilometers) per hour it would run 2,000 feet (609.6 meters) per minute. These speeds are not excessive, and are within the limits where a chain may be used with best efficiency.

The problem of driving dynamos on different types of motor-car engines is capable of many solutions. In some cases it is possible to secure a direct drive at engine-speed, through an Oldham coupling, and this is an instance in which the slow-speed dynamo may be used to great advantage. In many cases it is possible to extend the pump-shaft back through the pump-casing, and to obtain a direct connection in this manner. In other instances it has been possible to move the magneto and to install in the place formerly occupied by it a dynamo with a double-end shaft, to which the magneto is afterward connected by means of an Oldham coupling, and the two units driven in tandem fashion. This arrangement on a six-cylinder car requires a dynamo wound to deliver its output at 1½ times engine speed, that is, about 750 revolutions per minute. With the 1,000-revolution-per-minute dynamo, drive may be secured by means of a sprocket installed on the pump or magneto shaft, a sprocket on an extended half-time shaft, or one fastened to the crankshaft directly back of the clutch which engages the starting-handle. In other installations it is possible to drive by a gear, meshing with one of the timing-gears, or with one of those in transmission. Either of these last methods makes a very satisfactory installation where they can be used, as the gears, incased and running in oil, are almost absolutely noiseless. All of these methods and numerous others have been tried out and shown to be entirely satisfactory, both as regards noiseless operation and life. The remaining points to be considered are the size and capacity of battery to be used, and the method of wiring. In order to meet satisfactorily the severe conditions to which it is apt to be subjected, the battery must have plates sufficiently large to stand charging at the maximum dynamo output for an indefinite time, without deterioration. This condition would be imposed upon it by an automobile owner who drives only in the daytime. It should have sufficient capacity to maintain all lights on the car for six hours, and to carry the side and rear lights only, for from 20 to 24 hours, without receiving any charge. Exhaustive experiments have demonstrated that a battery with 160 square inches (852.3 square centimeters) or more of positive plate surface and 100 square inches (645.2 square centimeters) of negative-plate surface, is capable of standing a 10-ampere charging rate for very long periods, even when no current is taken from it. It is unquestionably possible to damage a battery of the above size by charging at a 10-ampere rate, if carried on indefinitely on a test bench. The condition of motor-car service, however, tends to offset the main causes of deterioration which become noticeable when the batteries are charged at high rates. In the first place, a battery charged continuously at a high rate becomes overheated, and this heat softens the plates to such an extent that they are readily disintegrated. Another cause of decay is the formation of large bubbles of gas on the negative plates, which, when they finally break away from the plates, take with them particles of active material, especially when this has become softened due to heating. The chance of overheating a battery due to continuous high-charging rates, becomes rather small when we consider that it is seldom, in practice, that a battery is charged continuously at the maximum rate for more than a few hours at a time. It is seldom indeed that a dynamo in motor-car service delivers its full output for several hours at a time without intermission, because automobiles are rarely driven at a continuous speed of 18 miles (28.9 kilometers) per hour, or above, for long intervals. In addition to the frequent slowing down of the motor-car engine, due to coasting downhill, or turning corners, there are often periods when it is not running, or is running slowly, so that the dynamo does not generate its maximum current. It has been proved in practice that in the average installation no appreciable heating takes place, and that even the drivers who maintain the highest average speed never raise their batteries to an excessive temperature. Referring to the second cause for deterioration, it will be evident that the vibration always present in motor-car service makes it practically impossible to form large bubbles upon the battery plates. The jolting of the automobile becomes practically a substitute for the mechanical agitator which is used in many large stationary battery plants. A battery installed on the average motor-car is operating under ideal conditions, as it is either charging or discharging nearly all the time. If the plate surface mentioned above is used, the 9½-ampere load represented by the total light equipment may be carried for approximately 3¼ hours, while the side and rear lights may be kept bright for at least 24 hours. It will be apparent that the 3¼-hour limit for the length of time during which the battery will take care of the entire load is hardly long enough, so that a battery used in a motor-car equipment should have approximately double the capacity given, or approximately 80 ampere-hours. In a very large number of lighting systems now operating successfully, standard makes of batteries rated at 80 ampere-hours with a 10-ampere discharge rate, are proving entirely adequate. A battery of this type has considerably more than the necessary plate area to stand the 10-ampere charging rate indefinitely, and will carry all lamps for at least six hours; a longer time than ordinarily required.

The remaining point now to be considered is the method of wiring, and type of wire used. In many of the first lighting systems, the proposition of a ground return for all fixtures was pointed out, but in practically all instances the system of running two wires to each lamp and fixture has been adopted. Ground returns in many cases brought about ignition complications, and the system of two wires has a decided advantage in that one conductor may be grounded accidentally without interfering with the lights. On the ground return system an abrasion or injury to the current-carrying wire is apt to put the entire system out of operation. In a recommendation to a special advisory committee of the Society of Automobile Engineers, Mr. Leonard Kebler, a member of the society, proposed that for motor-car installation a cable be used capable of standing a test of twelve hours' immersion in oil, twelve hours' immersion in gasoline, and twelve hours' immersion in water, and then stand 500 volts applied between the two conductors without a breakdown. Wire of this type has been used extensively by several manufacturers, and has been found to give excellent results. The insulation of wire for motor-car use should be composed preferably of some material which is not affected by oil or gasoline, and is not softened by ordinary temperatures. Where rubber is used, it should be protected against oil and gasoline.

In concluding, it may be said of the lighting system wiring that the manufacturer should, if possible, cut all wires to length, and make all connections before shipment. Experience proves that the highest satisfaction with motor-car lighting equipments may be obtained only when the wiring is done by skilled operators. Consequently, a lighting system designed in such a manner that it may be purchased for any particular make or model of car, with all wires cut to length and fitted with proper slugs, all connections possess distinct advantages.

American-grown versus Holland-grown tulips. Rows 1, 3, and 5, foreign grown. Rows 2, 4, and 6, American-grown.



The nucleus of a new American industry; a view of the Government bulb garden in bloom.

American-Grown Bulbs

Encouraging a Home Industry

By G. E. Mitchell

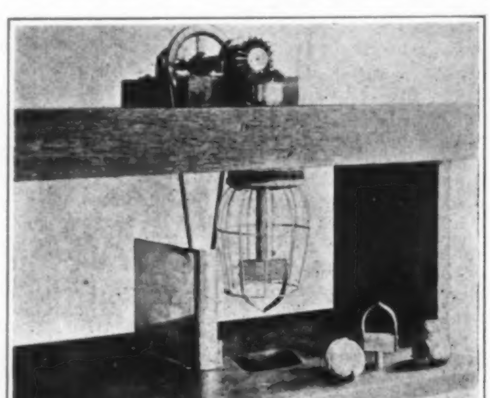
The Department of Agriculture expects to keep another $1,000,000 at home which is now annually exported, for Dutch bulbs—tulips, hyacinths, and narcissi. After repeated trials by florists and seedsmen in various parts of the country and as many failures, all attempts to raise bulbs of these popular spring flowers were given up and the industry was left to the Netherlands where the peculiar climatic conditions seemed to favor their development until finally in the Bellingham Bay region of Washington, as usually with most Old World industries, a place has been found where the bulbs cannot only be matured but better and earlier flowering bulbs are obtained than those imported. The Government has been maintaining for five years, with the co-operation of the Bellingham Bay Chamber of Commerce, a 10-acre bulb garden and the flowers which were raised this year are the largest, most gorgeous and perfect ever seen. The conditions at Bellingham are said to be quite ideal for bulb production.

True, the freight rate at present kills the bulk of the American markets in which they might be sold, but the Panama Canal will remedy this and put the State of Washington on an equal transportation footing with Europe and with a far better article in bulbs to supply the United States. In fact, even at this time with the matter in an experimental stage our Dutch friends across the water are more concerned over the situation than we are. They see their American million-dollar bulb income about to slip away, just as many other monopolies have done in the past.

The Bellingham Bay bulb garden is confined to hyacinths, tulips and narcissi, but there are scores of varieties and colors, and last year over 1,000,000 bulbs were planted. While the bulbs can be matured successfully in but few places in the world, the flowers from them can be successfully grown almost anywhere.

Hyacinths, in the eighteenth century, were perhaps the most favored flowers in Europe, and as much as 200 pounds sterling, or nearly $1,000 was paid for a single prize bulb; narcissus enthusiasts also have paid from $500 to $2,000 for a stock of a plant of special merit, while single bulbs of tulips have brought from 2,000 to 5,000 florins $800 to $2,000. Even to-day all three of these flowers are generally well liked and in great demand.

An interesting feature of the work at the Government bulb garden is the development of a scooping machine used in the propagation of hyacinths. The "mother" hyacinth bulb is scooped out so as to expose



Machine used to scoop mother bulbs. This machine will effect a saving of at least 25 per cent in time over scooping by hand.

the lower part of the scales just a little above where they unite with the base of the bulb. After scooping, the mother bulbs are put in trays and placed in the sun for a day for the purpose of drying the freshly cut surfaces. The trays are then placed in a well-ventilated and well-lighted propagating house. The scales soon separate somewhat, callus, and produce young bulblets, 20 to 30 from each "mother" bulb. About four years is required to grow these bulblets into salable flowering bulbs.

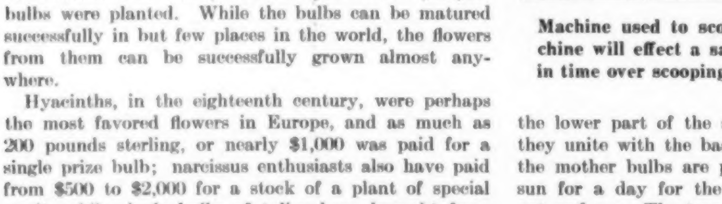
Both the Bellingham Bay bulb garden and the flowering garden at Washington City are sights to behold during the flowering season. Outside of Holland, nothing like them is to be seen anywhere—magnificent tulips, and hyacinths, of all colors and beautiful narcissi in a riot of profusion.

The remarkable showing already made and the large apparent profit from bulb-growing in this favored section of the northwest have already aroused commercial enthusiasm and will undoubtedly result in the establishment of the industry and the supplying of the country generally with a stock of virile and improved bulbs, even before the Government in its conservatism is willing to officially advocate their growing as a business enterprise.

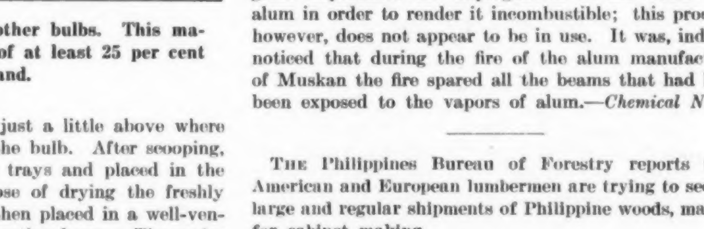
The Ignition of Wood

The substance the most employed to prevent the ignition of wood is silicate of potassium in solution; the wood is soaked in it, which protects it for a long time from all danger of inflammability. But several successive layers are necessary in order to arrive at a really efficacious immunization. The following is a good recipe: Thirty-five per cent of silicate of potassium, 35 per cent of sulphate of baryta, from 1 to 2 per cent of zinc white, and lastly 28 per cent of water; but it is not the only recipe. The greater number, however, are trade secrets. M. Wolff considers of great importance the impregnation of the wood with alum in order to render it incombustible; this process, however, does not appear to be in use. It was, indeed, noticed that during the fire of the alum manufactory of Muskan the fire spared all the beams that had long been exposed to the vapors of alum.—*Chemical News.*

The Philippines Bureau of Forestry reports that American and European lumbermen are trying to secure large and regular shipments of Philippine woods, mainly for cabinet making.



Imported and Bellingham-grown tulips in flower. The imported on left and domestic on right.



Mother hyacinths that have developed an excellent crop of young bulblets.

New Automatic Fire Alarm*

The Instrument Depends on the Use of a Conductor Having a Negative Temperature Coefficient of Resistance

By F. A. FitzGerald

FOR more than a year a very ingenious device for use as an automatic fire alarm has been the subject of considerable research work in the laboratory to which the writer is attached, and it is believed that a detailed description of it and its method of manufacture will be of interest.

GENERAL PRINCIPLE.

The fire alarm is the invention of Mr. Eugene Garretson. It consists in the use of a thermoscope in which the active element is a substance having a negative temperature coefficient of electrical resistance. The thermoscope forms part of an electric circuit, which also contains an alarm gong and indicating device, but has such a high resistance under normal conditions that the current passing through the circuit is not sufficient to work the alarm. If, however, the temperature of the air surrounding the thermoscope rises to a certain degree, the electrical resistance drops so as to permit the passage of sufficient current to give the alarm.

In Fig. 1 is shown the wiring diagram of a fire detector for two stations. The source of the current for the circuit is shown at G, the alarm gong at B, and relays with drops at R_1 and R_2, corresponding to the two stations protected with the series of thermoscopes T_1 and T_2 respectively. If the circuits are traced it is seen that they are complete only through the normally high resistance thermoscopes, and consequently the current is not sufficient to trip the relays nor to release the mechanical gong. Suppose, however, that a fire occurs in the room where the thermoscopes T_1 are installed, the resistance of one or more of these will be sufficiently lowered to permit the passage of current that will trip the relay

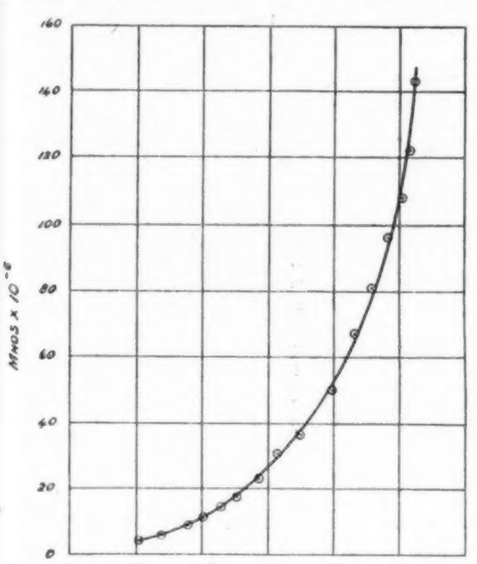


Fig. 2.—Curve showing increase in conductance.

R_1, thus indicating where the fire is and closing absolutely the alarm gong circuit.

THE THERMOSCOPE.

So far as the general principle of the invention is concerned, it is plain that a large number of substances might be used as the sensitive element of the thermoscope,—in fact, any substance with negative temperature coefficient; but for practical purposes the substance should have other qualities than the mere possession of a negative temperature coefficient.

A thermoscope of this kind should have the following characteristics:

(1) A very high resistance at ordinary temperatures.

(2) A large temperature coefficient, so that a small increase in temperature produces a large decrease in resistance.

(3) Its heat capacity should be small, so that as the resistance drops the increase in current, even though a very small one, passing through the thermoscope tends to heat it, and thus greatly increases the sensitiveness of the detector as the critical temperature is approached.

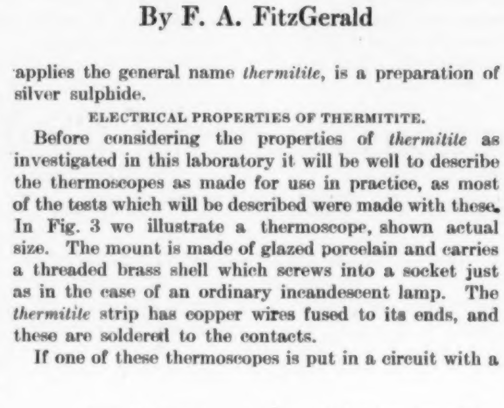
(4) Its characteristics should be permanent under all conditions to which it is apt to be exposed.

One of the best of the substances which have been found for this purpose, and to which Mr. Garretson applies the general name *thermitite*, is a preparation of silver sulphide.

ELECTRICAL PROPERTIES OF THERMITITE.

Before considering the properties of *thermitite* as investigated in this laboratory it will be well to describe the thermoscopes as made for use in practice, as most of the tests which will be described were made with these. In Fig. 3 we illustrate a thermoscope, shown actual size. The mount is made of glazed porcelain and carries a threaded brass shell which screws into a socket just as in the case of an ordinary incandescent lamp. The *thermitite* strip has copper wires fused to its ends, and these are soldered to the contacts.

If one of these thermoscopes is put in a circuit with a



Fire alarm circuit.

Fig. 1.—Wiring diagram.

small six-volt tungsten lamp and three dry cells connected in series the lamp will not light up; but if a lighted match is held under the *thermitite* the lamp almost instantly begins to glow with full candle-power. If the

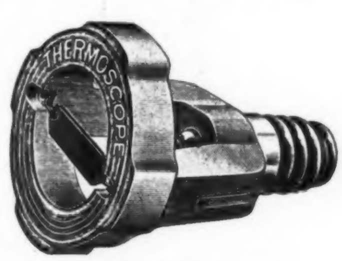


Fig. 3.—Thermoscope.

match is removed and the piece of *thermitite* cooled in any way the lamp is extinguished.

This, however, would not be the method when using the *thermitite* for a fire alarm, since that substance is an electrolyte, and, even though a solid, electrolytic changes might be expected were a direct current used in the circuit. That electrolysis does occur may be shown by the following experiment:

A piece of *thermitite* provided with silver electrodes was placed in a direct-current circuit for some time. Then the *thermitite* was cut out of the circuit and the electrodes connected to the terminals of a sensitive galvanometer which was immediately deflected, showing the generation of a current in the opposite direction to that which had been passed through in the direct-current circuit.

The experiment clearly shows a phenomenon-like polarization in an ordinary electrolytic cell. Obviously, then, in the use of *thermitite* as a thermoscope an alternating current must be used. It also indicates the necessity of using an alternating current in any attempt at making measurements of the electrical resistance of the thermoscope.

An investigation of the change of resistance of *thermitite* with temperature has been made with the express object of studying its action when used as a thermoscope. For this purpose a bridge was used, the current being supplied by a small induction coil and a high-resistance telephone receiver taking the place of a galvanometer. The thermoscope was immersed in an oil-bath heated by a coil of wire through which a current was passed. A rheostat was used to regulate the current so that the temperature of the oil-bath, which was kept thoroughly stirred, could be controlled. The result of one of these experiments is given in the curves of Fig. 2 and Fig. 4, where the abscissæ are degrees Centigrade and the ordinates are mhos $\times 10^{-6}$.

Referring to Fig. 2, the curve shows the increase in conductance from 4.3×10^{-6} mhos at 21 deg. to 143×10^{-6} mhos at 104 deg. Then a very abrupt change was observed, for at 105.5 deg. the conductance was $5{,}880 \times 10^{-6}$ mhos. This sudden change is shown best in the curve of Fig. 4, which is from the same observations, but plotted on a different scale.

Now it is not pretended that the curves shown in Fig. 2 and Fig. 4 represent the true conductance of the thermoscope at the corresponding temperatures. The temperatures are those of the oil-bath and not of the *thermitite* itself, which may be higher, owing to the passage of the current. The important point, considering the use of the *thermitite*, is that at a certain temperature in an electric circuit an enormous increase in its conductivity occurs.

In order to form some idea of how the thermoscope behaves when heated in air a different test is used. The circuit is similar to that shown in Fig. 1, and the thermoscope is put in an oven heated by means of a coil of nichrome wire through which a current controlled by a rheostat is passed. The temperature of the oven is raised until the alarm is given. This is found to be at approximately 80 deg. Cent. It is obvious from this test that the temperature at which the alarm is given is not the temperature of the *thermitite*, but merely that of the surroundings. This may be seen from the following calculations. In order to trip the drop of the 80-ohm relay a current of 0.04 ampère is required. The e.m.f. of the circuit is 6 volts, consequently the resistance of the circuit at the moment the relay works is

$$\frac{6}{0.04} = 150 \text{ ohms,}$$

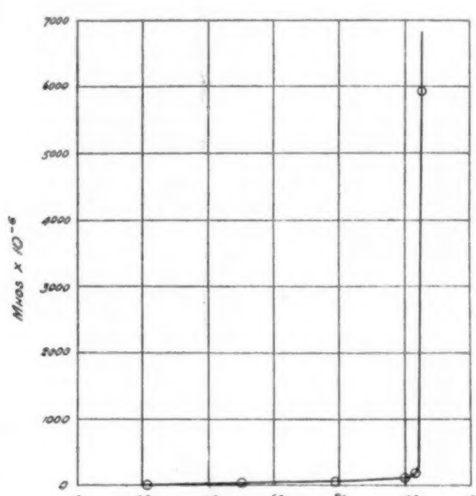


Fig. 4.—Very abrupt change in conductance curve.

but the resistance of the relay is 80 ohms, consequently that of the thermoscope is only 70 ohms. The oil-bath test showed that at 80 deg. the resistance of the thermoscope was 19,000 ohms, so it is plain that its temperature when the alarm is given is very much higher than that of the surrounding air. This, of course, is due to the heating effect of the current. Here we have an explanation of the great sensitiveness of the thermoscope, for it does not simply depend upon the heating effect of the air to cause it to give the alarm. Indeed, it would be more accurate to say that the thermoscope fails to give an alarm because of the cooling effect of the surrounding air, and that when this cooling effect is removed the thermoscope becomes a good conductor and turns in an alarm.

MANUFACTURE AND TESTING.

The process of manufacturing the thermoscopes is simple. The *thermitite* is made in sheets 0.5 millimeters thick, and from these oval-shaped pieces 10 millimeters long and 5 millimeters wide are punched out. Short pieces of No. 26 (B. and S. gage) copper wire are fused to the ends of these oval pieces, and they are then put in the porcelain mounts.

Every batch of *thermitite* is tested by finding the oven temperature at which the thermoscopes made from it ring in the alarm. The *thermitite* is also tested in an oven heated to 65 deg. Cent. to make sure that even at temperatures near the critical one it will not break down. Finally, all thermoscopes are mounted in large testing

* Reproduced from the *Journal of the Franklin Institute*.

boards and kept under observation for at least one month to discover if any defects develop.

FIRE TEST.

The tests for practical work are made as follows: In a room fitted with the thermoscopes a cone made of asbestos board is moistened with about 50 cubic centimeters of alcohol, placed on the floor under a thermoscope, and the alcohol ignited. This is quite sufficient to give the alarm, although a dial thermometer mounted beside the thermoscope fails to show more than a rise of 5 deg. Cent. in the temperature, nor after repeated tests has the slightest effect been observed on the varnish with which the wooden ceiling of the room is coated. No doubt, if the asbestos cone was not placed directly under the thermoscope it would be necessary to use a larger quantity of alcohol, but the test as performed shows that before the hot air about the thermoscope can even scorch varnish or cause a dial thermometer to register more than a few degrees rise in temperature the alarm is given.

PERMANENT CHARACTER.

In order to find out if the thermoscopes were permanent, some were mounted out of doors, where they would be exposed to all conditions of weather, with entirely satisfactory results. To test resistance to the action of chemicals several thermoscopes were mounted on the ceiling of our chemical laboratory where they are exposed to the acid fumes, etc., characteristic of such a room, and no deterioration has been observed up to the present time.

Reflections on Aerial Flight*

With a Note on the Fallacy of Pendulum Stabilizers

By H. R. A. Mallock, F. R. S.

Beginning with balloons, as having the priority in point of time, it may be remarked that the whole subject of aerial flight is included in the last 130 years dating from the experiment of the Montgolfiers, who made their first ascent in 1788, but were at work for some years before this, and that other designs quickly followed containing in principle most of the appliances which are in use to-day. The ballonet, for instance, was proposed and tried by Charles and Robert. We find also designs for dirigible balloons of much the same shapes as are now familiar to us.

All attempts at propelling these vessels naturally failed for want of adequate power, and in some cases the proposed form of propulsion was impracticable, but in others a screw of nearly the same proportions as that now in use was actually tried. It was soon found, however, that the speed which could be developed by man-power or by any engine that the balloon could lift only amounted to a few miles an hour, less, that is, than the speed of a very light breeze. Thus, so far as directing the course of a vessel was concerned, the mechanism was almost useless, and few further attempts at mechanical propulsion were made until the advent of the internal-combustion engine.

Independently of outward form, balloons may be divided into two classes, according as the lifting gas carried is (a) constant in mass, or (b) constant in volume, and these again may be subdivided according to the relation of the pressure or density of the enclosed gas to that of the surrounding air.

All the conditions, however, may be conveniently represented by supposing that the gas is contained in a massless vertical cylinder closed at the top by a fixed cover and below by a movable piston. The piston may be supposed to be free or clamped, and to be acted on by the gaseous pressures only or by any other additional force.

I do not propose here to go into the questions of the relative merits of the rigid and non-rigid forms, questions which turn on structural details rather than on general principles, but something may be said on the nature of the envelope used for retaining the hydrogen which is now usually employed for lifting purposes.

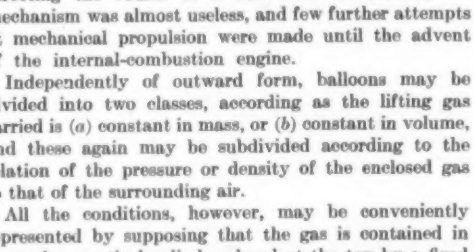


Fig. 2.—Stream lines of a perfect fluid.

The best information on the subject is due to work recently carried out at the National Physical Laboratory at the request of the Advisory Committee for Aeronautics, and will be found in detail in their published reports.

It appears that among the fabrics in use there are enormous differences in their retentive power (that is, in the rate of the diffusion of hydrogen through them irrespective of actual leaks), differences of nearly two hundredfold appearing between the worst and best specimens.

Indiarubber coatings are the least satisfactory, allowing an escape in some cases of more than 0.7 cubic foot for every square foot of material in twenty-four hours when new, and deteriorating as time goes on. The most retentive hitherto tested are various oiled silks, goldbeaters' skin, and some other artificial membranes.

When the large surface which all dirigible shapes expose to the air is considered, it will be seen how important is the choice of material, and that with the best the necessary hydrogen renewal is not a small matter, even if no ascents are made, and may well

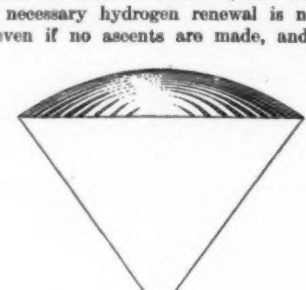


Fig. 1.—Diagram illustrating power required to maintain a fixed level.

be more than 1000 cubic feet a day for a moderately large vessel.

Much more than this, however, must be lost when the dirigible is in use. A thousand cubic feet of hydrogen gives a lifting force of about 75 lbs., and the engines of one of the larger dirigibles will part with many times this weight in fuel and other ways in less than twelve hours. To keep the vessel at a constant height the lift has to be diminished or the downward force increased at the same rate. While traveling this may be effected to some extent by steering, but when stationary the balance can only be obtained by allowing the equivalent amount of gas to escape. To rise again an equal amount of ballast must be discharged. The number of ascents, therefore, which can be made without a fresh supply of hydrogen is limited by the quantity of ballast which can be carried.

We may now direct our attention to the more promising field presented by true flying machines—machines, that is, which are heavier than air and are supported by the reaction of a downward current of air called into existence by the engines in ordinary flying or by the diversion of natural upward components of the wind in soaring. It is theoretically possible also to maintain flight (without expenditure of work on the part of the flying machine) in a horizontal wind the velocity of which increases with the altitude or varies from place to place at the same level. In this case the flying machine has to descend in the direction of the wind and then turn and ascend against it. In each such cycle work is gained, and the work is obtained from the difference of wind velocities.

One or two examples may be given illustrating the dependence of the power required on the terminal velocity.

First take the case of a parachute, which may be supposed to be massless and to carry a long ladder up which a man climbs (Fig. 1). If the man is to maintain a constant elevation above the ground he must be able to climb as fast as the parachute falls. Now it is known from experiment that a surface such as a parachute experiences a resistance while falling through the air equal to about 14-1000 of a pound for every square foot of area at a speed of 1 foot per second. If we give the parachute a diameter of 36 feet, its area will be about 1000 square feet, and if we suppose the man to weigh 150 lb., the terminal velocity will be given by $v^2 = \frac{150}{14}$ or $v = 3.3$ feet per second. This, of course, is much more than a man can do.

If we take a man-power as one-tenth of a horse-power, 55 feet per minute, or, at the outside, 1 foot per second, may be taken as the rate at which he can raise his own weight for any considerable length of time. The area which, when loaded with 150 lb., drops at the rate of 1 foot per second, is $\frac{150,000}{14.0}$, or 10,600 square feet, that is, a circle of 131 feet diameter.

With such a parachute a man could by climbing keep himself stationary in the air.

It is not necessary, in order to impart this momentum to the air, that the surface should itself have this area of 10,600 square feet. The same momentum may be given by a much smaller inclined surface moving horizontally.

If a perfectly efficient screw or inclined plane were a physical possibility, there would be nothing to prevent people from flying by their own muscular effort, and it is worth while to examine the causes which prevent the realisation of such a result.

We will now consider more closely the causes which produce the very marked difference between the theoretical curves given in Fig 2 and the corresponding quantities as determined by experiment.

It is well known that the fluid with which mathematicians deal, and which is supposed to surround the plane in Fig. 2, is an ideal body which is without viscosity (that is, opposes no resistance to shear), and that in contact with a solid it experiences no frictional retardation.

In such a fluid pressure and velocity are connected by an invariable law, the sum of the potential and kinetic energies of any portion of the fluid remaining constant for all time.

This law, together with the necessary condition of continuity, which for an incompressible fluid merely implies that the volume of a given mass of fluid remains constant, no matter what shape it takes, constitutes the foundation of all the propositions regarding the stream lines of a perfect fluid which have hitherto been

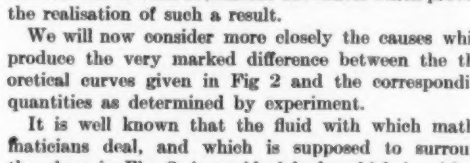


Fig. 3.—Frictional flow; stream oblique to plate.

worked out, and for such a fluid the stream lines indicated in Fig. 2 are an exact solution of the problem.

Now real fluids differ from the perfect fluid in having both viscosity and surface friction. They require that work should be done if distortion is going on, and they adhere to the surfaces of solids immersed in them. Thus a plane which, if moving edgewise in a perfect fluid, would meet with no resistance, does meet with resistance in a real fluid on account of the adherence of the fluid to the solid surface and the consequent distortion produced in the neighboring layers of the fluid.

It is true that for fluids such as water and air the viscosity is so small that the direct effects would hardly be noticeable. Indirectly, however, they have immense influence, and it is not too much to say that the most remarkable features in the flow of the winds, tides, and streams are due to the modification of stream-line motion set up by fluid friction and viscosity.

The indirect action referred to depends on the fact, that when a stream is retarded by friction the velocity is reduced, although the pressure remains unchanged,

* Abridged from the "James Forrest" lecture, delivered before the Institution of Civil Engineers and published in *Nature*.

and thus the fundamental relation which connects velocity and pressure in a perfect fluid is violated. So long as the stream concerned is of constant section and is neither accelerating nor retarding, as, for instance, when the flow is through a straight pipe of uniform bore, the effect of friction shows itself merely by rendering the stream lines irregularly sinuous, in a way which has not yet been investigated, and as giving rise to a resistance which is proportional to a power of the velocity something rather less than the square, *i.e.* to the 1.85th or 1.9th power.

When, however, the stream is divergent (so that in the absence of friction the velocities and pressures, although constant across each section, change from one section to another, but keep the total energy of the flow across each section the same), the effect of friction and viscosity is much more conspicuous.

On the up-stream side of the plane, friction does little to modify the conditions except in the neighborhood of the edges, but down stream we find, instead of a pond of still fluid, a complex wake consisting of a central current moving forwards towards the plane, bordered by a series of eddies the origin of which is of the same nature as those just referred to in the expanding channel, namely, to degradation of the streams passing round the edges of the plane, which, having insufficient velocity to follow the stream-line path of Fig. 2, are deflected inwards and become involved with the reversed central stream, about half the fluid in each eddy being supplied from up stream and half from the wake.

The eddies are formed periodically, growing to a certain size, and then, breaking away from their place of birth, they form part of the train which borders the wake current. The wake current itself is due to the constant removal of fluid in this way from the back of the plane, and the fact that the outflow from the back has its maximum velocity close to the edge where the composite eddy is being formed shows that the pressure on the back of the plane is lower at the edges than in the center. Hence it could be stated with certainty, even without any experiment, that the total resistance of a plane must be greater than $\rho v^2 \dfrac{\pi \sin a}{4+\pi \sin a}$, which assumes that the pressure over the rear surface is uniform and equal to the general pressure at a distance.

Experiment, however, is required to determine the actual resistance, and when the plane is broadside to the stream this is found to be about half as much again as the head resistance alone, or about 20 or 25 per cent greater than the dynamic head + the area of the plane.

When the angle α is small, as it always is in flight, the character of the wake takes the form shown in Fig. 3. Here the wake stream is only recognizable as a reversed current quite close to the plane, and the small eddies as fast as they are formed are so rapidly degraded that after traveling a short distance they are merely recognizable as slight variations in the direction of the general current.

The abstraction of wake water by eddy-making continues, however, even for very small values of α, and has the effect of deflecting the upper boundary of the wake as shown.

The deflection may be considered from another point of view as the outcome of the defective pressure on the down-stream surface of the plane.

The short account gives a general explanation of the observed difference between results calculated for the discontinuous flow of a perfect fluid and those actually found by experiments in air and water, and if the nature of the flow over the back surface were accurately known, the value of α for the maximum of L/R could be predicted. Even in the absence of this knowledge, the assumption that surface friction varies as v^2 and acts only on the up-stream side, leads to a value of α that is not far removed from truth.

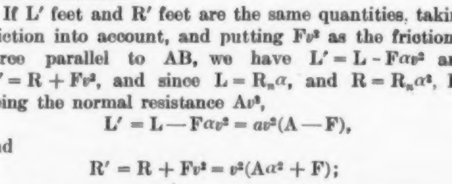
Let AB, Fig. 4, be the plane making a small angle α with the stream, and let L and R be the lateral force and resistance which would be experienced if there were no friction.

If L′ feet and R′ feet are the same quantities, taking friction into account, and putting Fv^2 as the frictional force parallel to AB, we have $L' = L - F\alpha v^2$ and $R' = R + Fv^2$, and since $L = R_n\alpha$, and $R = R_n\alpha^2$, R_n being the normal resistance Av^2,

$$L' = L - F\alpha v^2 = av^2(A - F),$$

and

$$R' = R + Fv^2 = v^2(A\alpha^2 + F);$$



hence $L'/R' = \alpha(A - F)/(\alpha^2 A + F)$, and this is a maximum when $\alpha = \sqrt{F/R}$.

Lanchester's experiments make F/R=0.0075; Zahn's experiments make F/R=0.0037, which correspond to $\alpha = 6.5$ degrees or 3.5 degrees respectively.

The actual value found from direct experiments on L and R lies between these two, and although 6.5 degrees is nearer the truth than 3.5 degrees, this does not imply that 0.0075 is the more nearly correct value of F/R, for the complete theory must take into consideration the action of the streams on both sides of the plane.

If ascending currents can be found, or if use can be made of differences of speed in the wind at different levels, there is no reason why engineless flight should not succeed, but the opportunities are rather limited.

The heaviest birds which can fly (great bustards, turkeys, and some of the vultures, eagles, and pelicans) weigh between 20 and 30 lbs. Of these, bustards and turkeys are short-winged, and the load is more than 2 lb. to the square foot of wing. But their flights are short and their wing movements rapid, and the power expended while rising from the ground must be very great in proportion to their size.

The large birds which make long flights have wing areas giving a load of less than 2 lb. per square foot, and are all adepts at making use of ascending air currents, so that for the most part of their time in the air they have but little work to do.

Much controversy has arisen on the question of the sufficiency of upward currents or upward components of currents of air to account for such flights, but the more the circumstances are examined the more clearly it appears that soaring is in most cases effected in this way, although the origins of the ascending currents are very various. Sometimes they are caused by natural

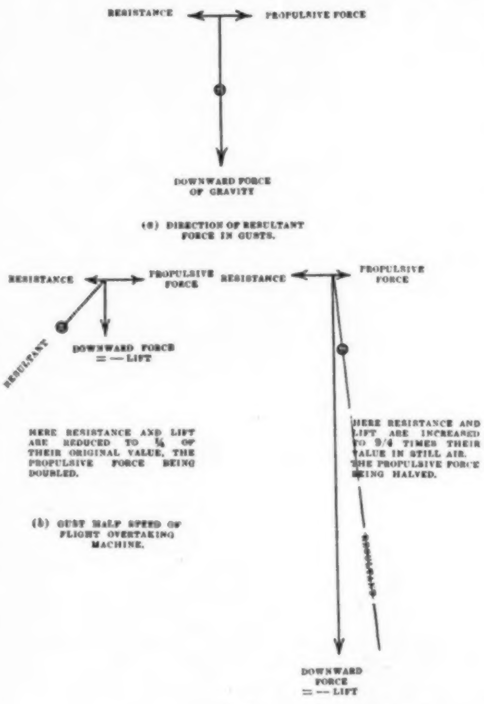


Fig. 5.—Three positions of pendulum carried on machine, corresponding to uniform flight, overtaking a gust, and opposing a gust.

obstructions in the path of the wind, such as cliffs, hills, the sides or sails of a ship, or the slope of waves, but on a larger scale they are chiefly the result of air ascending after having been warmed by contact, direct or indirect, with the ground. At low levels such vertical movements are very small, and at the surface of the ground any motion must, of course, be parallel to the surface; but at considerable heights, especially in sunny countries, these convection currents must always exist, even when the weather is calm, except in the rare event of large tracts of sea or country having the same temperature as the air in contact with them.

To anyone flying at a height, the sense of true vertical which we have, and by which we adjust our balance when standing or moving on the ground, is replaced by the direction of the resultant force of gravitation and any acceleration which the machine may be subject to. In still air or in a uniform wind, acceleration can only be the result of an alteration of level or of the engine speed, and the effects due to the latter cause cannot be very large or rapid. When, however, the machine passes quickly from a region of still air into a wind, or *vice versa*, which is what happens practically in gusts, the sensation of vertical direction is lost, and although the speed and direction of travel of the machine only change gradually, the resultant of the forces acting on it does so instantaneously, not only in direction, but in magnitude.

The three diagrams in Fig. 5 show the direction in which a short pendulum at the centre of gravity of the machine would point (*a*) when the flight is in uniformly moving air, (*b*) when in an overtaking gust, (*c*) in an opposing gust.

The connection between the angle (θ) which the pendulum makes with the true vertical being

$$\tan\theta = \frac{\text{Propulsive force} - \text{Resistance}}{\text{Lifting force}}.$$

It is hardly to be wondered at that such changes in the apparent vertical should be confusing to the pilot, and that accidents, which are often fatal, should happen while experience is being acquired.

Side gusts may produce still more embarrassing effects, the character of which depends on the class of machine and the disposition of the wings to a greater degree than is the case with gusts in or against the direction of motion.

At the present time the wings and framework of all machines are made as rigid as possible by wire stays, etc., with the result that the breakage of any one part is likely to wreck the whole, and it is probable that as time goes on more attention will be directed to increasing their pliability so as to allow a reasonable amount of distortion without crippling the structure. The problem of determining the greatest possible flexibility which can be given to a structure of a definite shape, size, and weight, which is also to have a definite initial stiffness, is theoretically capable of solution in terms of the strength density, and dynamic worth of the materials (by dynamic worth is meant the worth which can be stored elastically in the unit volume), and although I am not aware that any case has been worked out, the subject is worthy of investigation.

The most important questions which can be raised about flying machines relate to their stability in flight and the ease or difficulty of starting or stopping them, and on each of these questions I will say a few words. First, as to the theories of stability which have been given from time to time. Some of these I believe to be correct so far as they go, but none of them are anything like complete, since they are all based on the pressures and variations of pressure acting on the up-stream surfaces of wings and omit the variations due to the eddy formation which goes on the down-stream side.

Before proceeding further, it will be as well to define what I mean by stability in connection with flight. A flying body is stable if, when acted on by a propulsive force and the reactions of the air (but not steered), any small angular velocity imposed about a horizontal axis tends to die out, and any small displacement about a vertical axis to reach a constant value. Or, in other words, any accidental motion of the nature of pitching or rolling must tend to disappear, while an arbitrary twist to the right or left must put the machine on a new, but straight, course.

Technically, stability is compatible with the presence of forces which produce increasing oscillations as the result of disturbance; but for the present purpose not only must the average force so called into play be a restituent force, but the disturbing motions must also tend to die out. The oscillations, in fact, must be damped and not maintained.

None of the flying machines at present in use are stable in the sense in which the word is here used, but in the ordinary conditions of flight the eddies formed behind the wings are small and their period of formation so rapid that the change in the attitude of the wings (that is, in the angle a) which they can produce in one period is inconsiderable, and the stability or instability depends chiefly on the distribution of pressure on the up-stream surfaces, but the case is very different when the machine is passing through variable currents and the angle at which the air meets the wings is liable to large and rapid changes. The alterations in the arrangement of the pressures on the back surfaces are then much greater and take longer to go through their phases—long enough, in fact, to make the process of correction exceedingly baffling.

That flying machines should be unstable in ordinary circumstances is really of very little consequence. The same objection applies to walking. No conscious effort, however, is required to keep upright on *terra firma*, but on the deck of a small vessel in seaway we all know that sea legs are only got by practice, often involving many falls.

I think it very unlikely that any type of flying machine will be evolved which, without guidance, will be safe in bad weather, but it is quite possible that the necessary corrections should be applied by an automatic device, and if flight is to be anything but a fair-weather pastime, something of the kind will probably be found necessary.

What is required is an apparatus which will so trim the wings as to keep the machine related in a definite manner, firstly to the true vertical, and secondly to the direction of the resultant force at the time.

The various ways in which this could be done might furnish subjects for several lectures, and I will only say here that the many proposals which have been **made to use pendulums or gyroscopes to act directly**

on the correcting mechanism are bound to fail.

It is essential to the success of any automatic control that the forces called into play to make the corrections of trim should not react on the director of those forces, whether this is a pendulum or gyroscope or any other equivalent device. The only instance in which this condition has been fulfilled is the "steady platform" of the late Mr. Beauchamp Tower. In this Mr. Tower caused a gyroscope (which, in effect, was a pendulum with a very long period) to direct an axial jet of water on a group of openings connected by pipes to a series of rams in such a way that if the openings did not face the jet symmetrically water flowed into one or other of the pipes, and so altered the position of the openings until symmetry was restored, the restituent force having no tendency to alter the direction of the axial jet.

There may be other methods of attaining the same object in the case of wing-trimming or control for flying machines, but any device in which the correcting force tends to alter the position of the corrector is more likely to do harm than good.

The question of stability also becomes important when the flying machine is coming to the ground. In alighting, the machine either has to touch the ground at full speed and trust to retardation, supplied chiefly by the ground, for coming to rest, or it must alter the wing attitude with reference to the path so as to experience a greater resistance for a given lift. This latter method is adopted by birds when pitching on the ground, and in their case at the last moment is generally supplemented by flapping the wings when the velocity is so much reduced that the greatest lift the wing area is good for will not sustain their weight. Birds when pitching on any elevated perch, such as a bough of a tree or a rock, nearly always finish their flight in an upward direction; but neither this nor wing flapping is at present open to flying machines on account of the mechanical difficulties of construction.

Alteration of the trim of the wings, however, presents no great constructional difficulty, but when the angle between the wings and the path is large the effect of accidental variations of pressure due to eddy formation is more serious, and the instability is greater than when the angle in question is the gliding angle; and here, therefore, automatic correction would be very important. If this could be used successfully, a machine the flying speed of which was 40 miles an hour and which had a gliding angle of 1/7 could, as may be found from the resistance diagrams, reduce its velocity by alteration of the trim of the wings to 25 miles per hour before the weight ceased to be air-borne. Further, since for the whole time the resistance would average about one-fourth of the whole weight, the time taken in effecting the reduction of speed would be four times that required for gravity to generate the difference between 40 and 25, being 15 miles per hour. During this time—2.7 seconds—the average speed would be 32 miles per hour, and the machine would cover about 120 feet. These rough figures can be easily corrected from the curves giving lift and resistance for any particular machine, but there can be no doubt that it would be a substantial gain if the high speeds, which are becoming more and more common, could be quickly and safely reduced before reaching the ground.

It is quite possible to imagine a flying machine made with lifting screws, which would rise vertically from the ground and remain poised and stationary in the air; but no success has hitherto attended any attempts in this direction, partly because the inventors have not realized the very large blade area necessary for reasonable economy of power. One way of realizing the stationary condition would be to connect two flying machines traveling at the same speed in opposite directions with a length of rope and letting them circle round one another. No "banking" would take place, as the centrifugal force of each would be taken by the pull of the rope. If the latter were shortened as far as possible, the pair would, in effect, form a single machine with a lifting screw. The experiment would be dangerous, and is not recommended for trial, but is mentioned rather as indicating the size of the screw blades which the hovering type of machine would require.

In taking a general view of the present condition of the art of flying, it must be admitted that much remains to be done before it ceases to be a fine-weather sport, and I think the right course to pursue would be to try to evolve a type of machine which is fairly safe even in turbulent winds, and can arise and alight on the smallest possible area. When the essential features of the design which secures these results are recognized, the machines may be specialized for war or other purposes, and additional improvements may be introduced for convenience, comfort, or speed.

The opinion seems to be gaining ground that flying machines are more likely to be usefully developed than dirigible balloons, and in this opinion I fully concur, more especially as regards the larger dirigibles, which I have always considered too frail and too liable to accident to be of much real service.

All aircraft, whether heavier or lighter than air, will for some time to come be designed for the purposes of sport or war rather than for commerce, and although for war-machines cost takes a second place, it must be remembered that a dirigible costs rather more than a torpedo-boat, whilst a flying machine costs rather less than a torpedo. Further than that there are very few services to be performed by a dirigible which could not be carried out as well, or better, by a flying machine, the only, and rather dearly purchased, advantages attaching to the balloon being its power of rising quickly and of leaving the ground without the necessity of taking a run; and I think the best policy for us would be, while recognizing the occasional usefulness of dirigibles of moderate size (and building a sufficient number for experiment), to devote our attention chiefly to the elaboration of the most efficient means of destroying them.

From the purely scientific point of view it cannot be said that the ascents of any large balloon have added much to our knowledge.

The small balloons, however, recently used for carrying self-recording instruments have ascended to heights (60,000 feet or more) at which personal observation is impossible, and have brought back valuable information which could scarcely have been attained in any other way and although the records, as a rule, only deal with pressure and temperature, there is no reason why solar radiation would not also be measured by suitable apparatus. Such measures would give a better knowledge of the temperature of the sun than could be got by direct observation, even on the highest mountains.

In conclusion, and speaking generally, I may say that it seems desirable to encourage experiment on the widest scale, even if much of the work is not on strictly scientific lines; bearing in mind that great improvements may result from the working out of ideas which, as originally conceived, were unsound or even absurd, and that this is the more likely to be the case in such a subject as flight, for which, as I have endeavored to point out, a considerable part is not yet subject to accurate theoretical treatment.

APPENDIX.

The relative densities of different gases at the same altitude may be conveniently expressed in terms of heights of homogeneous atmosphere of each.

The height of the homogeneous atomsphere for a gas is defined as the height of a column of the gas if uniform density (equal to that which it has at sea-level) the weight of which produces the atmospheric pressure at its base. Thus the height of the homogeneous atmosphere Ha for air is in feet the number of cubic feet which weigh 2100 lb. nearly, and since 1 cubic foot of air weighs 0.080 lb., $Ha = 26{,}000$ feet nearly.

For hydrogen $H_h = H_a$ + the ratio of the densities of the two gases (namely, 16), so that $H_h = 416{,}000$ feet nearly.

If the distribution of temperature in the atmosphere is isothermal, the actual height (h) above sea-level at which the pressure is p is $h = H \log \frac{p_o}{p}$. Thus when $h = H$ the pressure is p_o/e, and the pressure does not vanish until an infinite height is reached.

If, on the other hand, the temperature decreases according to the adiabatic law (that is, if the temperature of the air at height h and pressure p is what it would be if with surface temperature to start with it was lifted without loss or gain of heat to the given height),

$$h = H\frac{\gamma}{\gamma-1}\left(1-\left(\frac{p}{p_o}\right)^{\frac{\gamma-1}{\gamma}}\right), \text{ or } H\frac{\gamma}{\gamma-1}\left(1-\left(\frac{\rho}{\rho_o}\right)^{\gamma}\right).$$

In this case, therefore, there is a definite upper limit to the atmosphere, for when $p = o$, $h = H\frac{\gamma}{\gamma-1}$ (rather more than 17 miles for air and 275 miles for hydrogen).

What the actual limit of the atmosphere may be is not known, but experiment shows that for the lower strata, at any rate, the adiabatic distribution of temperature is not very far from the truth.

If we have two short columns, one of hydrogen and one of air, of the same length, and both at height h, then (putting $H\frac{\gamma}{\gamma-1} = K_a$ for air, K_n hydrogen, and N for the ratio of the densities, ρ_a/ρ_n at sea-level, the density of the air at h is $\rho_a(K_a - h)^{1/\gamma}$, and of the hydrogen $p_n(K_n - h)^{1/\gamma}$.

If the balloon carries no weight it will ascend until the densities are equal, which occurs when

$$h = NK_a\left(\frac{N^{\gamma-1}-1}{N^{\gamma}-1}\right),$$

or, since $N = 16$ for air and hydrogen, and $\gamma = 1.41$, $N^{\gamma-1} = 3.1$, $N^{\gamma} = 51$, and $K_a = 17$ miles,

$$h = \frac{16 \times 17 \times 2.1}{50}, \text{ or } 11.5 \text{ miles},$$

and no hydrogen-filled balloon could ascend higher than this if the temperature was the adiabatic temperature.

The ascents of the balloons with recording instruments, however, lead to the belief that at heights exceeding 6 or 7 miles the temperature is constant, or nearly so, so that the practicable height of ascent may very considerably exceed the 11.5 miles just mentioned.

Monument to Noted Scientist

The committees formed at Amsterdam and Rotterdam have been engaged in collecting funds for a monument to the recently deceased scientist van't Hoff, and the monument is to be erected at Rotterdam, his native city, from designs of the sculptor Ch. Van Wyh of The Hague. It will be inaugurated in 1915, and the remainder of the funds will be used as an endowment for encouraging researches in pure and applied chemistry. It is probable that the Royal Academy of Sciences of Amsterdam will accept the rôle of administering the funds and awarding the subsidies.

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